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Bell Laboratories

RECORD

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- Versatility of TOUCH-TONE Calling
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- Blocking Filters for Coaxial Cables

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Bell Laboratories **RECORD**

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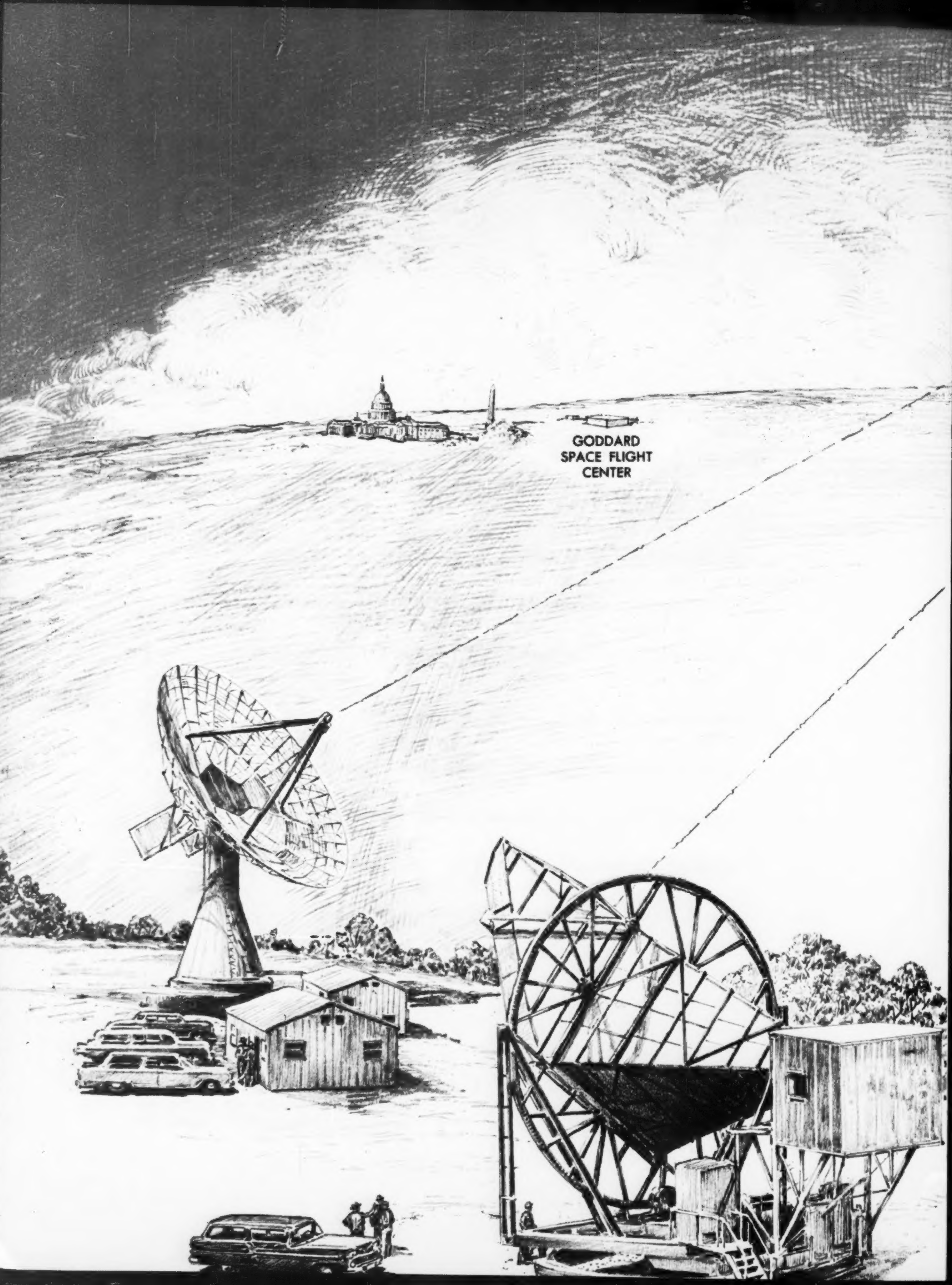
Cover *D. O. Melroy inserts traveling-wave tube into permanent magnet; new backward wave oscillator is in foreground. Both devices are new signal sources for radio research (see page 320).*


GODDARD
SPACE FLIGHT
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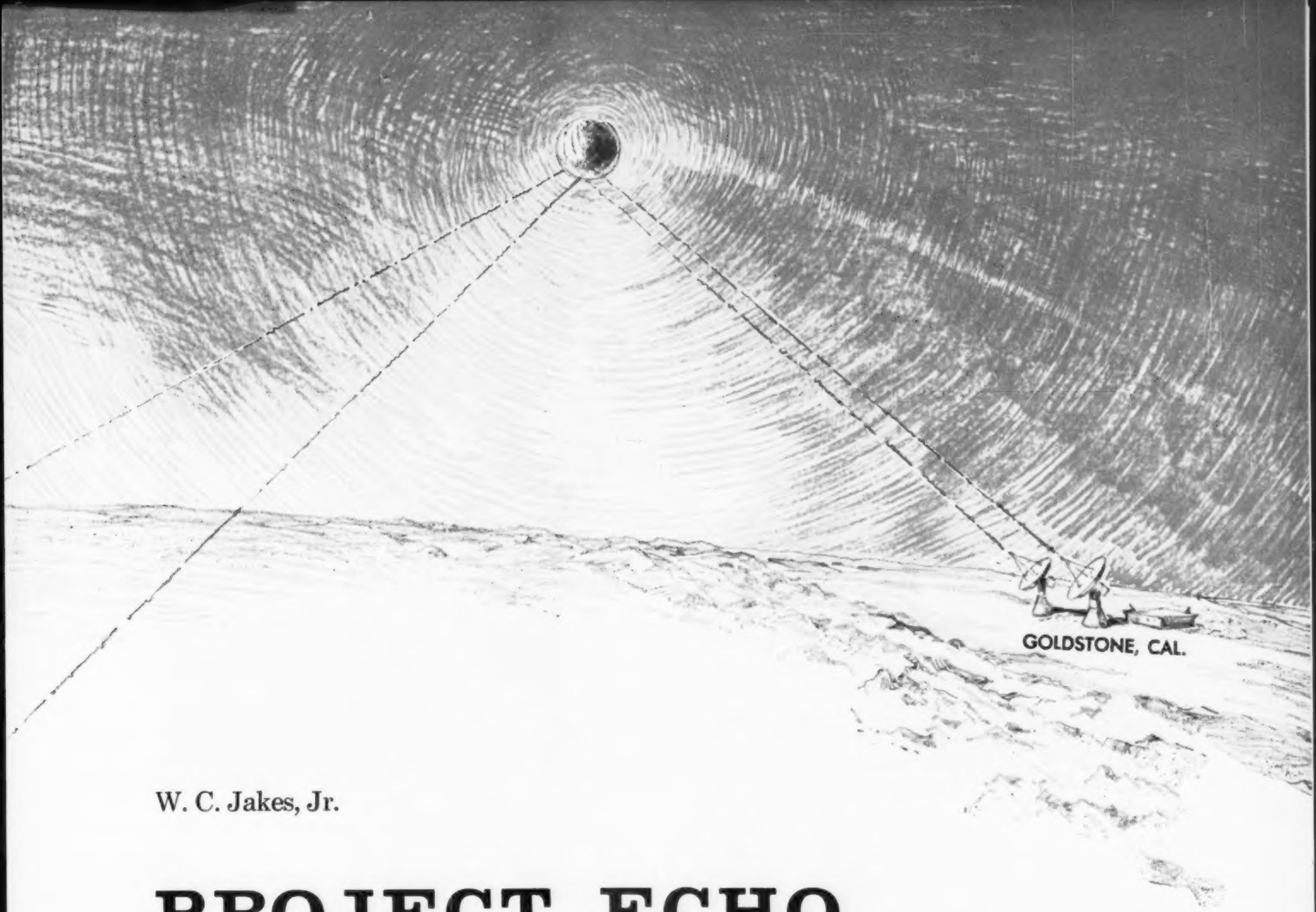


W. C. Jakes, Jr.

PROJECT ECHO

With a justified sense of accomplishment, the Bell System can point to its pattern of growth over the years. But behind the annual increases in numbers of telephone instruments installed and telephone calls made is a vast network of equipment connecting millions of customers to each other. Much of this equipment is involved with transmission, and includes open-wire lines, coaxial cable, and microwave radio.

Wire lines and cable are not always economical, however, and the available space for microwave frequencies is becoming more and more crowded each day. Thus the Bell System must keep looking for new paths to transmit messages if it is to keep providing growth in communications for its customers. For this and other reasons the Bell System recently cooperated with the National Aeronautics and Space Administration (NASA) in an experiment to study long-range communications by radio relay using an orbiting earth satellite.

The study has had as its focal point the much heralded Echo balloon which NASA put into orbit on August 12, 1960. This sphere of aluminized mylar has since been used as a target for microwave signals in tests to determine the suitability of a passive satellite for voice communications.

In the year that has passed since the balloon was launched, the participants in the Echo I experiment have accumulated a large amount of data which must be studied and evaluated. To appreciate these results, we perhaps should first briefly review what the experiment has required in terms of its system equipment.

The over-all arrangement for Project Echo communications consists of radio transmitting and receiving equipment and satellite-tracking equipment located at Bell Laboratories in Holmdel, New Jersey, and at the Jet Propulsion Laboratories (JPL) in Goldstone, California. Also participating in many of the tests have been the Naval Research Laboratory (NRL) with a station at Stump Neck, Maryland, the General Electric Research Laboratories in Schenectady, New York, and a number of organizations overseas.

Echo was directed into near-perfect circular orbit 1000 miles high by Bell Laboratories Command Guidance System.

A Thor-Delta missile containing a guidance system designed at Bell Laboratories placed the balloon in an almost exactly circular orbit 1,000 miles above the earth with an inclination of about forty-seven degrees to the equator. This provided the Laboratories site with mutual visibility of about 15 minutes with JPL and 25 minutes with NRL. The "slant range" from Holmdel to the balloon varied between 3,000 and 1,000 miles.

An east-west "channel" has connected a 60-foot paraboloid (or dish) antenna at Bell Laboratories to an 85-foot paraboloid at JPL via the balloon, on a frequency of 960.05 mc. A west-east channel, at 2390 mc has used transmission from another 85-foot dish at JPL to a specially constructed horn-reflector antenna at Holmdel.

The transmitter at Holmdel provides a 10-kw output for two signals. One signal, the communications channel, is centered at 960.05 mc. The other is centered at 961.05 mc, and is used for the tracking radar. The power output in each channel may be independently varied from 0 to 10 kw as long as their sum does not exceed 10 kw. Normally the communications channel is set to 7.5 kw and the radar channel to 2.5 kw. Characteristics of the transmitter can be monitored.

The 60-foot parabolic antenna can be positioned accurately to 0.05 degrees in winds up to 35 mph, at angular rates more than adequate for satellite tracking. From the feed horn to the transmitter output, the transmission line is waveguide, except for a short section of coaxial cable required for the two rotating joints.

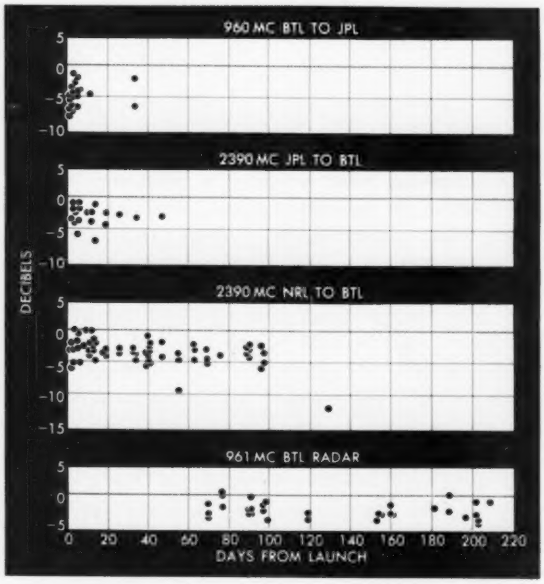
For receiving 2390-mc signals. Bell Laboratories has used the special horn-reflector antenna, primarily because of its demonstrated low-noise properties. In this antenna, the throat of the horn tapers to round waveguide inside an antenna cab. A rotating joint, having very low loss, couples the horn to the waveguide system.

The receiving system for the horn-reflector contains two maser amplifiers—one for each component of polarization of the incoming signal. Both are immersed in liquid helium in the field of a single magnet. In the event of maser failure, a dual 2390-mc parametric amplifier has also been provided, and can be switched into the system in place of the maser in a few minutes. The remainder of the receiving system is located in a control building and includes FM feedback demodulators, a four-channel pen recorder, a frequency monitor, and audio recording and distribution equipment.

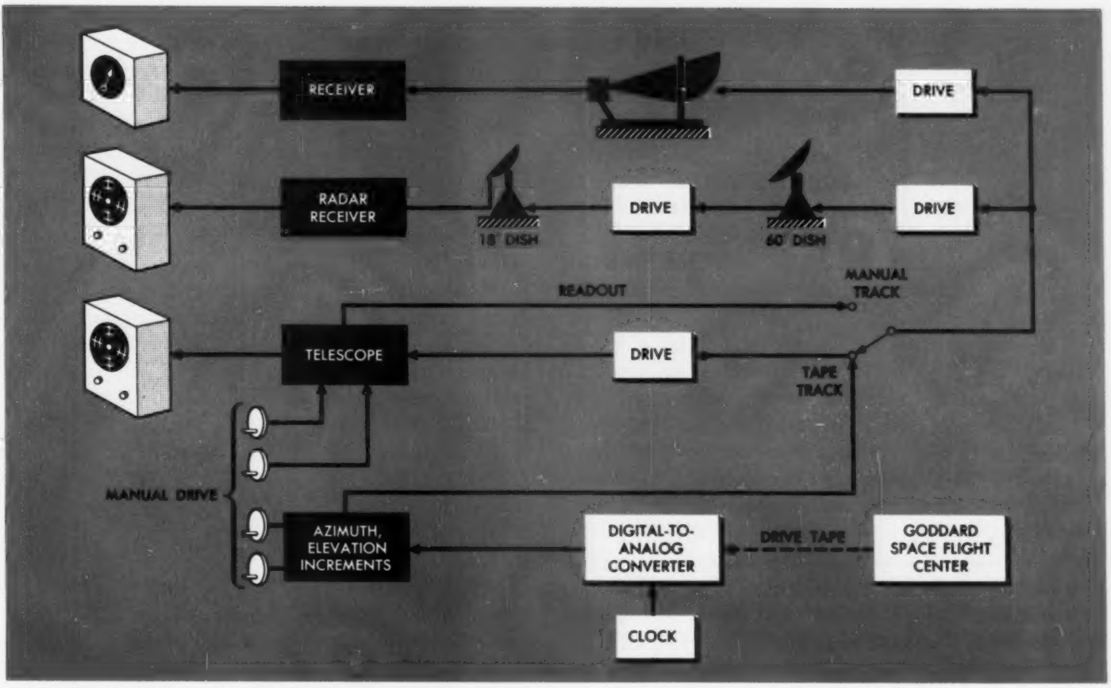
Laboratories engineers anticipated difficulty in tracking the satellite accurately enough to achieve hoped-for signal levels, and therefore set up a number of different methods of tracking. Primarily, the entire system was slaved to a teletypewriter tape containing predicted "look" angles for a given satellite pass. This tape was based on calculations of the orbits made at the Goddard Space Flight Center, Greenbelt, Maryland, from observations obtained from the center's Minitrack network—a series of radio-receiving stations spotted around the world.

During actual passes of the balloon, any differences between the position called for by the tape and the actual satellite position were corrected by information derived from optics, radar, or the radio signal. Alternatively, if no drive tape was available and if the satellite was visible, the system was slaved to the optical system which was then manually operated to track the satellite.

A Digital-to-Analog Converter (DAC) converts the digital information in the paper drive-tape to the analog (synchro) positional commands for controlling the antennas and optics (RECORD, *April*, 1961). The drive tape supplies, every four seconds, five separate quantities in a block called a "data point." Each data point gives time, azimuth, elevation, azimuth rate, and elevation rate of the satellite. These quantities appear on the tape in binary-coded decimal form—four bits for the digit and one for a parity, or error, check. The decoding equipment in the DAC uses the rate information to derive positional commands in between the four-second data points,



Measurements of scattering cross-section show change in shape of balloon over long period of time.



Steering information on the Echo satellite to and from the drive tapes is derived by three different methods. These are the optical tracker, the radar receiver, and information from radio signal itself.

and as a result, the antennas move smoothly.

For the first several months after launching, the computer at the Goddard Space Flight Center supplied the drive tapes. Since the beginning of 1961, most of the tapes have come from a computer at the Whippany location of Bell Laboratories, based on orbital elements supplied by the Smithsonian Astrophysical Observatory in Cambridge.

The drive tapes are read photoelectrically at a time corresponding to the time of the data point. As the tape advances from one point to the next, the angular quantities are read into transistorized logic circuits where they are sorted and decoded. The decoding process results in a rectangular pulse output whose duration corresponds to the input quantity, causing a motor to turn a gear to the appropriate angular position to an accuracy of 0.02 degrees. Fastened to the gear train are a number of synchro transmitters which supply positional command signals to the transmitting dish, receiving horn, and optical drives. The DAC also includes a stable clock for the time comparison in reading drive tapes.

The tracking telescope mounts on a large trailer and includes a periscope-type optical train leading to convenient operator positions inside. The telescope has a field of view of six degrees with a magnification of 8X. It can be slaved to the command signals originating from the DAC, or manually controlled to follow an object while sending suitable positioning signals to the antennas. Normally, the operator watches through the telescope while it moves in accordance with the commands derived from the drive tape. Then, if he detects errors, he inserts appropriate angular offsets, causing all the system antennas and the telescope to track the target accurately.

Tracking Radar

A separate tracking radar with an 18-foot paraboloid receives the 961-mc signal reflected from the satellite. A conically scanned beam of the radar obtains the angular position of the satellite with respect to the system axis. Error signals from the receiver then go to the optical trailer where they position the spot on a cathode ray tube. This shows the position of the satellite with respect to the system-pointing axis in much the same way as the tracking telescope. The operator manually inserts proper angular offsets to center the spot.

NRL has a single 60-foot dish equipped either to transmit or receive at 2390 mc. Ordinarily, both Bell Laboratories and NRL would receive JPL during the first part of a satellite pass while there was mutual visibility between Goldstone

and Holmdel. After the balloon had "set" for JPL, NRL would then transmit to the Laboratories. On a few passes, JPL and NRL simultaneously transmitted to Holmdel and the two signals were recorded on the Bell Laboratories receivers.

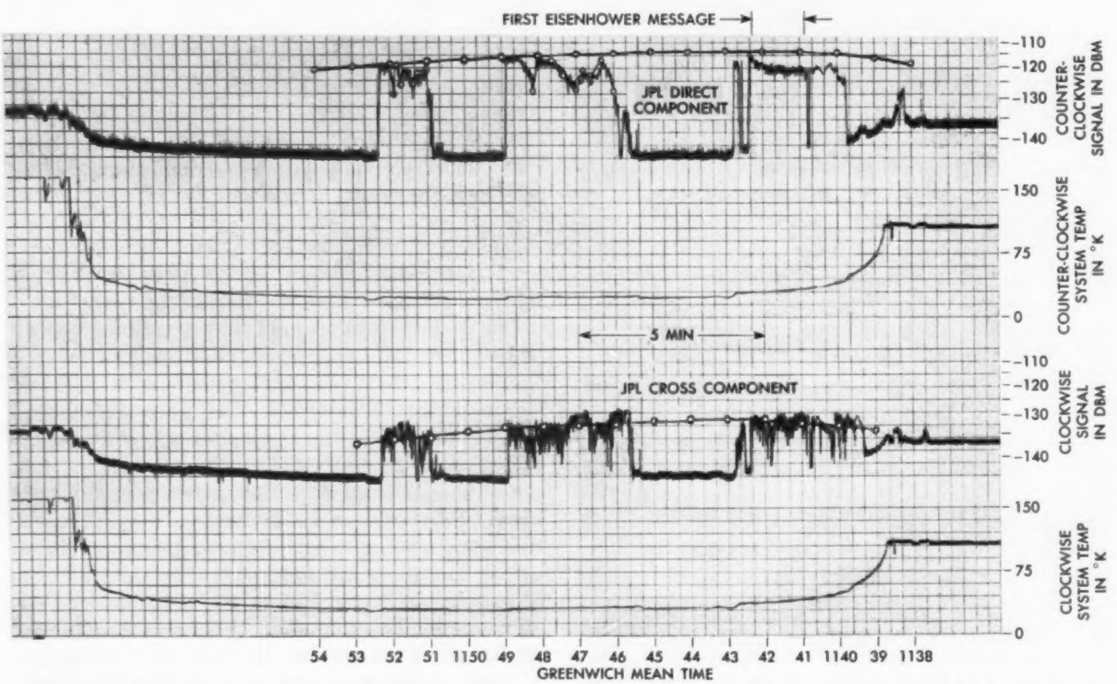
The communication tests were carried out primarily using frequency modulation with a special feedback arrangement invented over twenty years ago at Bell Laboratories. Other types of modulation were also available, including single sideband and narrow-band frequency, or phase, modulation.

Since the successful launching of the Echo I balloon, various operations, involving more than 150 passes of the satellite, have been carried out by Bell Laboratories. In general, the Laboratories project engineers feel they have achieved the objectives of the experiment. For example, measurements of the signal-to-noise ratio in the audio band were made during many of the passes for modulated signals. These measurements were very close to the predicted values for all types of modulation used. The quality of voice or music using FM feedback was excellent, and indistinguishable from that of a landline circuit. A successful demonstration of facsimile took place in September in which a photograph was transmitted from NRL to Holmdel via the balloon (RECORD, *October*, 1960). The project engineers have concluded that the balloon, in conjunction with the existing terminal equipment, provided an excellent circuit in the designed bandwidth of 200-3000 cps. Furthermore, any communication service that could be transmitted in this bandwidth could be handled equally well by the satellite circuit.

Comparison of actual received power with that predicted has been made for many passes at both 960 and 2390 mc. In general, the engineers found that the observed values differed from the predicted values by an approximately constant factor during the significant portion of most passes. On several early passes the average "scattering cross section" was equal to that corresponding to a perfectly conducting 100-foot sphere. From this it is assumed the balloon inflated as planned.

There apparently has been a long-term decrease, of a few db, in the average "scattering cross section." As of last May, Echo I was probably an approximately spherical object with a diameter no less than 70 feet, and a somewhat wrinkled skin. There may have been a few flattened areas, as indicated by occasional deep fades in the radar signal, but voice communication was then still possible as shown by successful tests with NRL on May 25.

Indication of near perfection in the launch and



Four-pen recording of first pass of satellite, August 12, 1960, showing polarization signals, temperatures.

guidance from Cape Canaveral came during the first passage of the balloon over the United States. At this time a signal was received from JPL for three periods of one to three minutes duration. The gaps in reception were caused by incorrect data points on the drive tape. The balloon could not be seen at Bell Laboratories during this pass because of cloudiness, and, since the radar was still relatively unproven, tracking was done by inserting appropriate angular offsets from the 2390-mc receiver. The drive tape used was prepared before launch and corresponded to the planned trajectory. Obviously, had the launching not been virtually perfect, there would have been no reception at all on the first pass.

Successful transmission took place from the Laboratories to JPL at 960 mc on a number of passes during the first eleven days after launch. At that time it was quite evident, from the steady signals, that tracking was excellent and that the balloon had a fairly smooth surface.

Later, occasional signal peaks greater than expected were observed. This is consistent with the hypothesis of a slightly distorted balloon surface. There may, for example, have been one or more flattened areas, any one of which could return more signal than the entire balloon when it was round. Or, it is possible that several signals reflected from these separate areas could add in phase, thus producing a signal stronger than that possible from a round balloon. Similarly, these various components could interfere destructively, and it is probably this mechanism that produced an occasional deep fade in the signal.

Probably the best example of a completely successful pass involving both JPL and NRL was the 70th, occurring several days after launch. By this time, the drive tape predictions were accurate to within a few tenths of a degree and personnel at all locations had become quite proficient in tracking and station operation. The level of received signal from both JPL and NRL agreed closely with theory almost throughout the pass.

Operations on subsequent passes were similar to those on pass 70. But the effects of shrinking became more and more pronounced, as shown by the increased scintillations of the received signal. By the end of 1960, the scintillations were fairly large, and the average signal level had dropped several db below the calculated value.

Greater scintillations were observed on all passes at low elevation angles of the satellite. This can be explained to some extent by operational effects, such as difficulty in acquiring and tracking the balloon at long range, but it is also probable that anomalous propagation through the earth's atmosphere contributed to the fading.

The DAC proved to be very reliable, requiring only minor repairs and adjustments. Occasional errors in pointing while the DAC was slaved to the drive tape were usually caused by errors in the tape itself. Moreover, DAC's error-checking circuits prevented about 90 per cent of these errors from appearing in the output positioning signals.

During each pass of the satellite the project engineers attempted to assess the accuracy of the drive tapes by appraising the angular offsets required to track the balloon. The results show that the predictions deteriorated progressively, with errors increasing from about 0.2 degree in August, 1960, to about 1 degree by December.

Several factors were responsible for these errors. For example, solar activities caused anomalies in upper air density. This effect became more pronounced as solar radiation pressure increased the eccentricity of orbit and the balloon traveled through denser air during part of each orbit. Also, the tracking beacons on the balloon itself gradually grew weaker, until, by the end of December, 1960, the signals were virtually useless for accurate determination of the orbit.

Additional Experiments

During the course of the Echo experiments, occasional tests were carried out with stations other than the principal participants. Transmissions were attempted, for example, to Jodrell Bank, England, using AM for voice and music. Reception was also reported at 960 mc by Centre Nationale d'Etudes des Telecommunications, France on August 18. On two later passes, CNET again reported receptions with a 30-foot dish which tracked the satellite optically.

Successful transmissions of a carrier signal to Malvern, England, occurred on three passes on August 29 at 960 mc. Also in August, Bell Laboratories transmissions at 960 mc were heard by the General Electric Company in Schenectady, New York. Later, a number of two-frequency transmissions were made with G. E. to study the amplitude and phase correlation of the signals.

Project Echo is now virtually completed. From it, a great deal of information has been filed on the properties of a satellite relay from microwave communications. But Echo I is a *passive* device, and to extend our knowledge of space communications, experiments must also be carried out with active repeaters. Only by such tests can we obtain the information needed to permit us to design working commercial systems.

The Versatility of

The fact that TOUCH-TONE Calling can be made to work with systems designed for rotary dials only begins to show its versatility. A host of applications in information processing await this system which transmits signals as musical tones.

H. E. Noweck

TOUCH-TONE Calling

The "pushbutton," once a symbol of relaxed living in the distant future, is rapidly becoming an accepted fact in our every-day life. By pushing buttons we can drive our car, tune in our favorite radio or TV program, or control any number of other electrical appliances. The word "pushbutton" has become practically synonymous with speed—convenience—the effortless accomplishment of laborious tasks.

To most Americans, the symbol of telephone service—the home telephone set—is facing an evolutionary change of marked importance. In place of the spinning dial with its circle of holes, the new telephone will have a series of ten pushbuttons to transmit the called number to the switching equipment in the central office. These ten pushbuttons will be lettered and numbered in the same way as the holes in the present dial, and will be arranged in three rows of three buttons each for numerals one through nine, with the tenth button—the "zero-operator" button—centrally located in a fourth row.

The telephone user will operate the buttons sequentially to establish a connection in the same way he dials digits sequentially at present. In contrast, however, the pushbuttons may be operated at a speed limited only by the capability of the user; there will be no waiting period as is now needed to let the dial return to normal before dialing successive digits.

The customer will be conscious of the change in his station set. But this is a small part of the totally new signaling system that has had to be developed—a new type of signal generator in

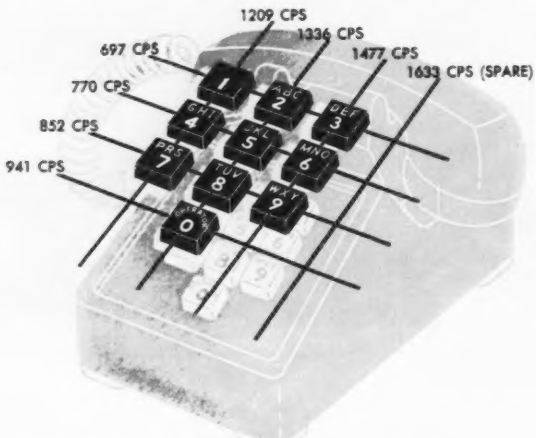
The supermarket of the future may be marked by the absence of clerks and shoppers and presence of automatic equipment operating under orders of TOUCH-TONE signals coming from customers.

the station set, a new signaling method, and a new type of signal receiver in the central office. The new signal generator and receiver use the latest achievements in electronic components and techniques.

In the new system, depressing a button momentarily generates musical tones that identify the digit. Each digit is represented by a different combination of two out of a total of eight tones. Although this system has a maximum of 16 different tone combinations, only ten are required for transmitting the necessary digital information to establish a connection to the called number. This leaves six combinations available for anticipated, but as yet unfocused, needs. Some possibilities are discussed later. Designers have selected frequencies for the signaling system to minimize the possibility that similar frequencies, present in speech, music, and noise, could imitate a legitimate digit and thus cause wrong numbers.

The signaling "language" of the present dial and that of TOUCH-TONE Calling are totally dissimilar. Since our existing central-office equipment was designed to understand dial "language," an automatic "translator" has been designed to translate TOUCH-TONE language into one that present central-office equipment can understand. This will allow the Bell System to introduce TOUCH-TONE Calling gradually while it continues to use equipment in which it has a multi-billion-dollar investment.

The method of access to these translators, or converters, and indeed the converters themselves, differs with the various switching systems. In this respect, the major divisions among systems are step-by-step and common control; that is, panel and crossbar.



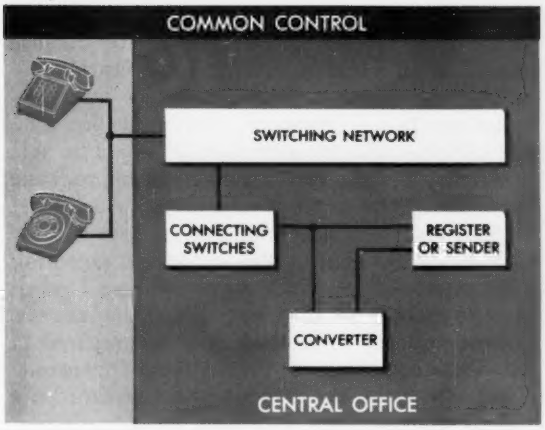
Each digit is represented by a combination of two unique tones. Six combinations are future spares.

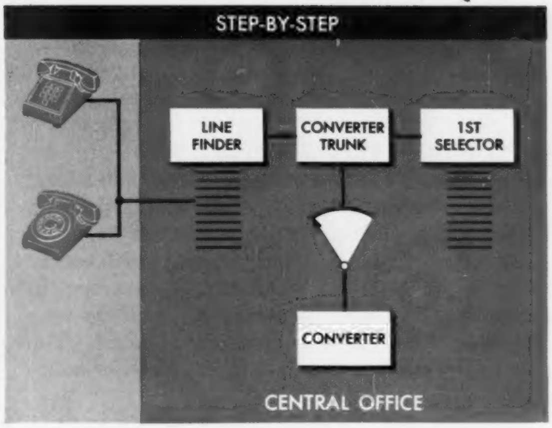
Let's first take a look at common-control type offices. In these offices, at the start of every call, switches connect a register or sender to the calling line to receive and register the called number as dialed by the customer. Modification for TOUCH-TONE Calling consists of permanently associating a converter with each register or sender that is to receive pushbutton signals. And here there is a very vital and fundamental difference among the different common-control systems. In No. 5 crossbar, for example, the originating registers may be readily subgrouped into pushbutton and dial-pulse subgroups, so that only registers required to handle traffic from pushbutton lines need be equipped with converters. The selection of a register of the proper type is assured by a "class-of-service" indication given by the calling line. In panel and No. 1 crossbar, however, it is not economically feasible to segregate senders according to a class-of-service; therefore, all senders must be equipped initially with converters.

It is the function of the converter to change TOUCH-TONE Calling signals into a form usable by the register or sender regardless of the type of common-control system involved. However, the converters become increasingly more complex as we go from the No. 5 crossbar converter, the simplest, through panel and No. 1 crossbar, and finally to the most sophisticated converter in the step-by-step switching system.

The converter for the No. 5 crossbar system consists of the basic building block common to converters of *all* switching systems—a multi-frequency receiver—and a "buffer" unit whose function is to transform the 2-out-of-8 output of the electronic TOUCH-TONE portion of the receiver into a 2-out-of-5 input. The latter is recorded directly on the existing digit registers of the No. 5 crossbar originating register.

Now let's look at panel and No. 1 crossbar systems. Here, the converter is associated with originating senders, and is a bit more complex since digit storage and outpulsing facilities are added. This is done for two reasons. First, the speed at which digits can be transmitted with a pushbutton set can exceed the capabilities of the devices that register the digits. This is particularly true in the case of No. 1 crossbar senders where the digits are registered on a crossbar switch. Second, by having the converter outpulse at 20 pulses per second, the conversion to dial pulses can be made with a minimum of modification to the sender and with *almost* full advantage being taken of the greater speed inherent in pushbutton operation.





In common-control systems, converters are appliqued directly to senders or registers. In the step-by-step system, access to the converters is through trunk interposed in switching network.

So, in the case of panel and No. 1 crossbar, the most economical arrangement is that in which the converter receives multifrequency signals from the pushbutton set, stores them on digit registers, and outpulses them into the senders at 20 pulses per second.

In step-by-step offices, a converter trunk is interposed between the line finder and the first selector. The trunks have access to the converters through an added switching linkage which serves to reduce the number of converters by as much as twenty to one.

Converter Action

The converter accepts pushbutton signals and generates dial pulses to operate the step-by-step switches. In the case of a call from a rotary dial station, the converter repeats the first digit to the first selector and then "cuts-through" the converter trunk and releases during the first interval between digits. The rest of the dialed digits directly control subsequent stages of selection in the usual manner.

As in the case of No. 5 crossbar, the step-by-step conversion arrangement lends itself readily to partial conversion by segregating pushbutton lines in separate line-finder groups. This results in substantial economies in the early stages of conversion as compared to converting the entire office.

Since a step-by-step office cannot do its own translating, the converter includes a modest amount of pretranslation ability. This permits the converter to look at the initial digits and determine how many more to expect on each call. Pretranslation minimizes converter holding time, and thus the number of converters required, by permitting the converter to release as soon as it has received and outpulsed the expected number of digits. Outpulsing in this case is at a rate of 10 pulses per second because of the limitation imposed by the step-by-step switches.

Some step-by-step offices are arranged for Automatic Message Accounting, and the recently developed Automatic Number Identification system. These arrangements require "party test" action which is normally made by the outgoing trunk. However, for pushbuttons, the converter is inserted in the transmission path at the time that party test is normally made. Thus the converter must make the party test and simulate the proper condition toward the trunk connecting the system to AMA or ANI. In all systems, the converter is "transparent" to dial pulses so that both dial and TOUCH-TONE types of stations can be associated with a given line.

There are apparently, then, no barriers to linking TOUCH-TONE Calling to present telephone equipment. However, a compatible customer service only begins to tap the potential usefulness of TOUCH-TONE Calling.

Signals generated by a dial cannot travel easily beyond the local central office. But the tones generated by a pushbutton set are in the voice-frequency range and may therefore travel over any established connection used for voice transmission. Thus the possibility of "end-to-end" signaling and the availability of spare signals will open up a whole new world of exciting and commercially attractive customer services. These will be based on the remote control of devices, particularly those of the computer type.

Already the Bell System has put to work one of these services in Western Electric Company distributing houses. Operating Company installers at the present time prepare written orders for needed equipment. These orders are received at the Western Electric distributing house where clerks process the order. This manual handling is time consuming, error-prone, and expensive. To solve this problem Western Electric designed a new system using a new simple card reader which works with a DATA-PHONE data set to transmit the required ordering information over telephone lines to a central card punch. The punched cards are fed into a card reader associated with a computer.

Each installer (or other authorized person) has his own number to uniquely identify him. The computer is programmed to recognize his number, not only as a name, but also his ordering authorities in terms of total dollars and specific quantities of individual items, and his delivery address. Each item to be ordered has its own number as well.

Ordering Operation

In using the system, the installer places a telephone call to the central point, inserts his identity card and follows it with cards of each item to be ordered. He uses a keyset on the card reader to key in the quantity of each item. The system uses error checking and different tones to indicate an "OK" transmission or one in error. In case of error, the operation is repeated.

It is possible to extend the idea of using the TOUCH-TONE set as a manual slow-speed data transmitter to many fields including telemetering, supervisory control, and control of information storage. In the latter category would be uses for air line and hotel reservations systems, interrogation and changes in inventory accounts, production accounting, and mechanized filing systems.

One particularly intriguing application of TOUCH-TONE Calling is the concept of an "automatic store" which is in reality an automatic supermarket. Present-day shoppers, however, would not recognize such a supermarket. There would be no check-out clerks, no shopping carts, and most significant of all, no customers. Instead, the supermarket would resemble a warehouse with enormous storage bins, conveyor belts, and automatic packaging machines.

The busy housewife of tomorrow would simply take her TOUCH-TONE set and, using a coded grocery list appearing in the daily papers, order the food supply for her family from this automatic store. She would not have to identify herself or the order verbally. Instead, automatic number identification would be used for identification and billing; the TOUCH-TONE set would be her slow-speed data transmitting, or ordering, device. Special equipment at the supermarket would be able to identify the housewife, and select and package her order. The order would then be delivered to her house, almost free of human intervention.

Whether the uses of the end-to-end signaling capabilities of a TOUCH-TONE set are immediate or lie in the future, they bring problems the system engineer must study and be prepared to answer. Among these are the effects of transmission facilities on the frequency and levels of the signals, compatibility with data receiving equipment, effects of polarity reversals encountered in some switching systems, and ways to make the system resistant to customer errors.

Tentatively, some of these problems have already been solved. For example, encoding plans have been derived which circumvent the customer's tendency to transpose digits. Also, plans have been drawn to make the oscillator in a TOUCH-TONE set independent of the normal signaling conditions in the switching system.

Conversion of a telephone system to TOUCH-TONE Calling is a long-range problem involving tens of millions of telephones, hundreds of millions of dollars, and years of time. Thus, planning and implementing the uses of this facility will require the most careful thought to insure that we take full advantage of all its potentialities.

D. G. Tweed demonstrates model of TOUCH-TONE telephone that has had experimental trials.

Testing wood preservatives for use in outside plant structures requires long evaluation. This new technique offers possibilities of reducing the time necessary to obtain meaningful data.

R. A. Connolly

Measurements of Strength Reduction Reveal Wood Decay

The Bell System uses some 21,000,000 wooden poles to support its wires and cables, as well as substantial numbers of other wood products such as crossarms, planks, and reinforcing stubs. All this wood is, of course, subject to decay and must be adequately protected with preservatives. Many different materials have been tested over the years, in the continuing search for the most efficient protectant. These tests, to be meaningful, require a standard measuring technique which will reveal the relative effectiveness of a preservative after normal and accelerated aging.

In the United States the standard technique for determining the effectiveness of wood preservatives is the soil-block bioassay, developed at Bell Laboratories some years ago (BELL SYSTEM TECHNICAL JOURNAL, *January*, 1946). This technique is now an ASTM Standard (D1413-56).

In this assay, ¾-inch test cubes of southern pine sapwood are weighed and placed on small untreated pieces of the same species of wood, called feeder strips, which have been inoculated with a fungus. The feeder strips in turn rest on top of soil in 8-ounce bottles. This test set-up is shown at left on page 320. During a prescribed incubation period, the fungus is in contact with the test cubes. At the end of this period the cubes are weighed again, and the weight loss is used as a measure of the amount of attack by the test fungi. Although this test is an accelerated laboratory method, it still requires from nineteen to twenty weeks to evaluate specific preservatives.

Obviously, any improvement in the procedure that would yield reliable results in less time would be highly desirable. One logical candidate to investigate as an alternate procedure was the effect of decay on wood strength. Biologists have long known that decay causes large reductions in strength, considerably in advance of even small reductions in weight. Toughness and impact strength are the specific mechanical properties affected most rapidly. They are also affected to a greater degree than other mechanical properties. In addition, the use of strength measurements as criteria of wood decay in laboratory tests have been investigated to some extent in Germany,

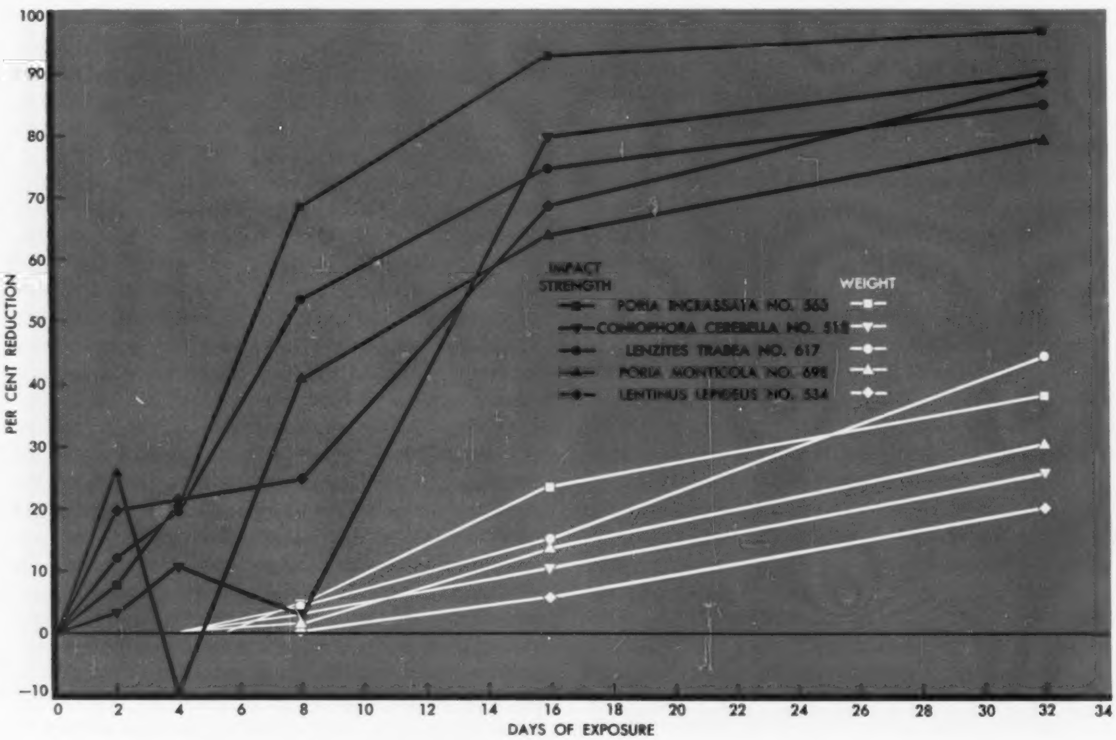
England, Portugal and India, as well as in the United States. None of these studies used the soil-block technique however.

Consequently, the Outside Plant Development Department at the Laboratories began a test program to determine the practicality of shortening the soil-block test by measuring reductions in strength rather than weight to judge the extent of fungal attack. The first samples to be tested were untreated, to eliminate the complications introduced by preservative treatments in investigating such factors as: (1) the relationship of weight loss and strength reduction; (2) the effect of different test fungi on strength reduction; (3) the variability to be expected; and (4) the time necessary to obtain an adequate amount of strength reduction. Measurements were made of changes in impact strength rather than toughness because they were easier to make and the necessary calculations were simpler.

After deciding on the type of mechanical test to use, the best size and shape of the test sample had to be determined. Rapid decay could be promoted by keeping the surface-to-volume ratio large, especially with a small sample. Thin sheets of veneer were considered first, but after examination of various samples of southern pine veneer, it was apparent that selecting test samples that were reasonably uniform with respect to texture, density, and freedom from checks would be a major obstacle. Consequently, it was decided not to use veneer specimens for this test.

The customary southern pine feeder strips currently used in the soil-block procedure measure 1.375 x 0.750 x 0.125 inch, and thus qualify as small samples. Also, the stock from which they are cut is carefully examined for straightness of grain, freedom from knots and other defects, and number of growth rings per inch. For routine testing, these feeder strips seem to be about as good a sample from a quality standpoint as might be obtained and were chosen for the initial studies. The only change made in the soil-block test procedure was the replacement of the ¾-inch test cube by this feeder strip.

Two methods of exposure were used in an effort to determine the exposure that was most conducive to rapid decay, and whether impact strength was a suitable criterion for evaluation of such decay. In the first method, the test specimen



Reductions in wood strength and weight after exposure in horizontal arrangement to various fungi.

(one per bottle) was laid horizontally on top of the usual feeder strip set-up so that it was at right angles to the inoculated strips. In the second method, the test sample was buried vertically, with half its length in the soil, and the upper half above the soil line and in contact with the edge of a single inoculated feeder strip. Bottles containing samples under each of these exposure methods are shown on page 320.

The basic test plan for both methods called for the investigator to expose groups of ten untreated samples to each of five different fungi. Each test was repeated with varying periods of incubation. The fungi were Madison strains, obtained from the U.S. Forest Products Laboratory, and included *Coniophora cerebella* (Madison 515), *Lentinus lepideus* (Madison 534), *Poria incrassata* (Madison 563), *Lenzites trabea* (Madison 617), and *Poria monticola* (Madison 698). The samples were exposed to a different fungus for periods of 2, 4, 6, 8, and 16 weeks.

A total of six hundred samples was used, divided evenly between each exposure method. In addition to plotting strength data, the investigators measured weight loss on every sample by conventional methods for purposes of comparison.

After the samples had been exposed to the fungus for the prescribed period of time, they were removed from the bottles and stored under constant temperature and humidity conditions until they reached equilibrium. They were then tested "to destruction" by impact bending. The data on weight loss and strength reduction for the horizontal exposure method for all five test fungi are shown on the opposite page. The graph shows the striking contrast between the two measurements—the relative reduction in strength in even the mildest case was far greater than any of the weight-loss percentages. The strength losses ranged from 78 to 97 per cent in contrast to weight losses ranging from 20 to 44 per cent. Of all the fungi, *Poria incrassata* caused the greatest reduction in strength. It was also responsible for a relatively high weight loss.

The data for the samples exposed vertically showed considerably less difference between values for reduction in strength and weight, although the values for strength reduction are still high (38-86 per cent compared to values of 5-32 per cent for the weight loss). *Lentinus lepideus* and *Lenzites trabea* caused greater strength reductions under this type of exposure than the other three organisms. Actually, the amount of strength reduction resulting from these organisms is reasonably close to that observed in the horizontal position, but apparently horizontal exposure favored the growth of certain of the other organisms, particularly *Poria incrassata.*

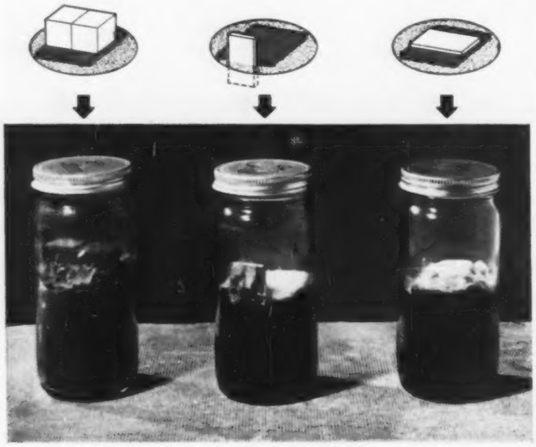
Mrs. G. A. Reynolds catches "hammer" of Izod impact tester, after breaking wood test sample.

By its very nature, wood is not a homogeneous material, and it is impossible to eliminate all irregularities for test purposes. Thus, the strength reduction curves for both exposure methods are erratic between 0 and 8 days. In fact, several curves for both exposure methods indicate an actual increase in strength during this period. This occurs because variables such as density, texture, and grain play an equal or more important part in strength performance in the early stages than does the fungus, which has just begun to grow in the sample. This explains the large majority of the inconsistencies during the first eight days.

The reason for the differences between the two exposure methods probably lies in the fact that feeder strips in the horizontal position offer a flat surface with a reasonably uniform, optimum moisture content on which the fungi can grow. In contrast to this, the vertical strips probably have a somewhat higher moisture content at and below the ground line than above it, because of direct contact with the moist soil. Although the different wood-destroying fungi vary somewhat with regard to optimum moisture content of wood for decay, exposing the test piece horizontally to the atmosphere in the jar seems to result in better conditions for uniform decay in this test. Because

of the substantial difference between the strength reduction by the two methods, only horizontally exposed samples will be used for future tests.

Strength reduction thus appears to be a promising method of evaluating decay in the soil-block test on untreated samples, especially in view of the possibility of savings in time up to 50 per cent which have been demonstrated in these experiments. Strength tests are no more difficult to run than weight-loss tests, and actually involve fewer measurements and less handling. Tests are now under way at the Laboratories using the method with treated test pieces, in the hope that they will show a similar trend. These tests involve feeder strips treated with both pentachlorophenol and creosote, the most widely used preservatives



Diagrams at top illustrate methods of exposure used in testing fungal attack. Left—standard soil-block bioassay; center and right—vertical and horizontal arrangements of feeder strips.

for Bell System telephone poles. The data from the first tests, using feeder strips treated with creosote, are encouraging. Of course, treated samples do not lose strength as rapidly as do the untreated specimens, but after 30 days exposure to *Lentinus lepideus* the strength loss is significantly greater than corresponding weight loss, as determined by conventional soil-block bioassay.

Naturally, a test of this type is only a good laboratory method if it is reproducible. Much more work is needed to establish this aspect even with respect to creosote. The studies with pentachlorophenol have not yet progressed to the point where trends are evident. It will be a matter of time before this method can be thoroughly tested, but the data so far suggests that it could provide a more rapid and meaningful evaluation of the chemicals used as wood preservatives.

Light Amplifiers and
Discussed at

Audiences at the 1961 Western Electronic Show and Convention last month heard speakers from Bell Laboratories describe recent developments in many fields. Among them were descriptions of the operation of an optical maser as a light amplifier, and the development of two new continuous-wave power tubes, powerful signal sources operating in the 50 to 60 kmc range.

Ruby Optical Maser Amplifies Light

In the optical maser experiments, P. P. Kisliuk and W. S. Boyle of the Solid State Research Department set up two ruby masers in tandem. A pulse of light from one maser, operating as an oscillator, was beamed into the other. Amplification of the light by a factor of two was observed.

Although it has been known previously that maser oscillators amplify light enough to make up for losses at the end mirrors, this is the first publication of results obtained in an experiment designed to observe and measure such large amplification directly.

The difficulty in observing amplification directly is that of distinguishing coherent maser light from the natural fluorescent light of the maser. In the experiment by the Laboratories scientists, this problem was solved by using a ruby maser oscillator to generate a coherent light which was so bright that the amount of fluorescence from the amplifier ruby was comparatively small. The amplifying ruby maser was similar to the light-source maser except that the ends of its ruby rod were not silvered.

The two rubies were fired simultaneously. The output from the amplifying ruby was measured by a photomultiplier tube. Both the signal going into the amplifier and the signal coming out were displayed on a dual-beam oscilloscope.

Gain was measured by comparing the output-to-input ratio, when using the amplifier, to that obtained when the amplifier was removed from

Power Sources WESCON Meeting

the beam. The amount of gain that can be obtained depends on the temperature of the amplifying maser and the pumping power. The net gain of a factor of two was observed at -40°C. Mr. Kisliuk said that with a more precise experimental setup and greater control of temperature, it undoubtedly will be possible to obtain a larger amplification.

He also said that the potential applications of optical masers are just being explored, and that maser amplifiers may eventually be as important to communications as maser oscillators.

In a discussion of the two new power tubes, D. O. Melroy of the Electron Tube Development Department told the WESCON meeting that a 50-milliwatt backward-wave oscillator and a 0.5-watt traveling-wave tube, both with permanent magnet circuits, are providing versatile signal sources for general laboratory use.

The backward-wave oscillator operates in the frequency range from below 45 to over 60 kmc. It gives at least 50 milliwatts power from 50 to 60 kmc and the output power fluctuates less than 2 db over the same range.

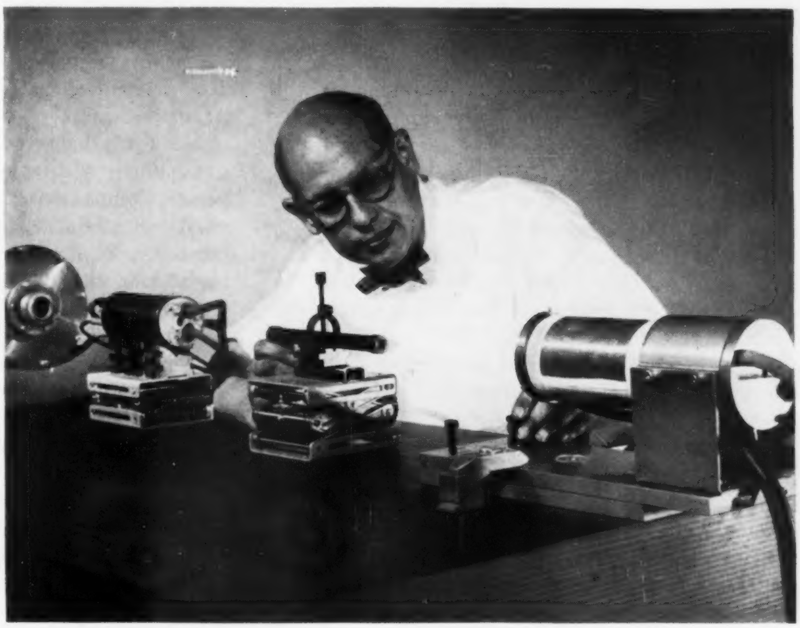
New Power Sources Generate Signals

The traveling-wave tube is a helix-type tube that provides more than one-half watt of power from 50 to 60 kmc. The low-level gain is 40 to 45 db at midband and shows a slope of about 6 db across the 50 to 60 kmc band.

There is sufficient power from either tube to extend greatly the range of measurements possible at 50 to 60 kmc, and to permit the use of levelers, ratio meters and other devices which are commonly used to facilitate measurements at lower frequencies.

Mr. Melroy said that during the past year many tubes of each type have been in operation at Bell Laboratories in the program to develop a millimeter-wave transmission system. Each unit includes permanent magnets to focus the electron beam, and internal transducers to match it to standard waveguide. No external matching devices are required.

As yet, no life studies have been made. However, several tubes have been in operation over 1000 hours with no signs of failure.



P. P. Kisliuk adjusts the collimator which directs a beam from ruby maser oscillator (right) through the ruby maser amplifier (center) to the photomultiplier tube at the left.

F. R. Kappel

E. J. McNeely

F. R. Kappel Elected Chairman of Board; E. J. McNeely Elected New President of A. T. & T.

After almost five years as president of the American Telephone and Telegraph Company, Frederick R. Kappel was elected Chairman of the Board of Directors at a meeting of the directors on August 16. Mr. Kappel will continue to be the chief executive officer of the company.

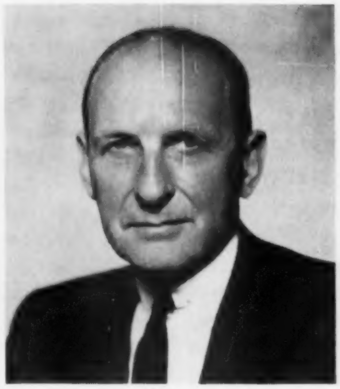
Eugene J. McNeely was elected to succeed Mr. Kappel as president. Mr. McNeely has been an executive vice president of the company for the past six years.

The directors also elected William C. Bolenius, executive vice president of A.T.&T. since 1958, as vice chairman of the Board of Directors, and elected James E. Dingman, vice president and chief engineer of the company, to succeed Mr. McNeely as executive vice president. Claude M. Blair, formerly vice president in charge of staff of the Pacific Northwest Bell Telephone Company, was elected a vice president of A.T.&T. He will be responsible for space communications programs.

Mr. Kappel started his Bell System career as a groundman with the Northwestern Bell Telephone Company in 1924. After holding various positions of increasing responsibilities in that company, he became assistant vice president of operations in 1939. Three years later he was elected vice president of operations, and a director of Northwestern Bell Telephone Company.

Mr. Kappel came to the A.T.&T. Co. in January, 1949, as assistant vice president, Operation and Engineering. In February of that year he became vice president of the Long Lines Department and in November returned to the Operation and Engineering Department as vice president. He remained in that post until he was elected president of the Western Electric Company on January 1, 1954. Mr. Kappel returned to A.T.&T. when he

W. C. Bolenius



J. E. Dingman

C. M. Blair

was elected president on September 19, 1956.

Mr. McNeely joined the Bell System in 1922 as a student engineer with the Southwestern Bell Telephone Company, after receiving his degree in electrical engineering from the University of Missouri. He was named division plant engineer in Kansas City, Mo., in 1925, and the next year moved to St. Louis in the same capacity. Three years later he was named area plant supervisor in St. Louis. From 1929 to 1932 Mr. McNeely was division construction superintendent for the state of Arkansas.

In 1932, he became district plant superintendent, East St. Louis, Ill.; then division plant superintendent, first at Little Rock, Ark., then at Kansas City. In 1941 Mr. McNeely returned to St. Louis as assistant general plant personnel supervisor and the next year became general plant personnel supervisor for the company. Two years later he was named plant superintendent for Eastern Missouri and Arkansas. In January, 1947, Mr. McNeely was appointed general plant manager for Southwestern Bell.

Mr. McNeely was named assistant vice president—personnel relations for A.T.&T. in 1948. He was elected vice president of the Northwestern Bell Telephone Company in 1949 and later that year became president of that company. Mr. McNeely returned to A.T.&T. in 1952 as vice president—personnel relations and remained in that position until 1954 when he was named vice president—operation and engineering. Mr. McNeely was elected executive vice president of A.T.&T. Co in October, 1955.

Mr. Bolenius, new vice chairman of the A.T.&T. Board of Directors, joined the New York Telephone Company in 1921 and served in various traffic positions until he was elected vice president and general manager of the New York Company in 1943. In 1946 he went to the Wisconsin Telephone Company as vice president and general manager and later that year he became president of that company. Mr. Bolenius was elected vice president—personnel relations in 1948 and later vice president—finance, of A.T.&T. He became executive vice president of A.T.&T. on September 19, 1958.

Mr. Dingman, new executive vice president of A.T.&T., began his Bell System career when he joined the Western Electric Company in 1922. He held various positions in the Long Lines, New York and Southern New England Companies before he was elected a vice president of the Bell Telephone Company of Pennsylvania in 1949. He was vice president—personnel, and later vice president—operations of that company. In 1952 he was elected vice president and general manager of Bell Telephone Laboratories. Mr. Dingman returned to the Long Lines Department in 1956 as director of operations. He has been vice president and chief engineer of A.T.&T. since December, 1959.

Mr. Blair, who will be in charge of space communications programs, joined the Long Lines' plant department in 1930. Before he was appointed assistant treasurer of A.T.&T. in 1957, he held many positions in the Long Lines Department and served in both World War II and the Korean War. In 1958 he was elected vice president and general manager—Colorado of the Mountain States Telephone Company. In 1960, Mr. Blair was elected vice president of Pacific Telephone-Northwest, and later, when the Pacific Northwest Bell Telephone Company was organized, he continued as vice president in charge of staff of that company.

A method of removing water that enters buried plastic insulated conductor cables through sheath breaks has been developed at the Laboratories. This method solves some difficult maintenance problems on these transmission routes.

N. Becker

Removing Water From Buried PIC Cable

When the Bell System Operating Companies began to bury plastic insulated conductor (PIC) cable for trunk and toll routes, they encountered a maintenance problem that was unique in Outside Plant experience. This was the occasional need to remove relatively large quantities of water which entered the cable through accidental sheath breaks. Buried cables may traverse wet or swampy areas, or heavy rains may cause temporary flooding of the cable route. When an accidental sheath break occurs in the presence of external water, the water may enter the cable and cause circuit trouble.

The manner in which a leaky buried cable responds to an external head of water is characteristic of the insulating material—paper or plastic—of the conductors. In a paper-insulated cable, the insulation fibers soak up moisture close to the sheath break and swell to form a plug against the entrance of more water. Simultaneously the insulation resistance of the conductors drops to a low value. This is an immediate warning of circuit trouble and to repair the cable under these conditions is not difficult. Using routine methods of electrical measurements, maintenance personnel can pinpoint the wet spot and dig down to and repair the cable.

PIC cable, however, acts differently. The plastic insulation on the individual conductors is impermeable to water and does not swell to form a plug. Moreover, the insulation has very few imperfections that expose the metallic conductors. Therefore, the water may travel a considerable distance through the cable before reaching a point where it creates a low resistance leakage path between two conductors or between a conductor and the metal component of the sheath.

The problem of finding a method which could

be used in the field to remove water from buried cable was presented to Bell Laboratories. The solution ultimately indicated by Laboratories' engineers involved adapting to the case of buried cables a procedure long known in chemical laboratories—the displacement and solution of water in another liquid. But before we describe that procedure it may be informative to chart the general attack upon the problem. Accordingly, this article will first consider a few methods which, though mainly rejected, all centered on a unifying idea—evaporation of water from the cable.

Alternate Methods

The simplest method considered was to evaporate the water by passing dry air through the cable. However, calculations proved this was impractical at substantially atmospheric pressure because of the large amount of air or other gas consumed. For example, approximately 10,000 cubic feet of air is needed to evaporate one gallon of water with dry air at atmospheric pressure and at a temperature of 60 degrees F. In addition, the time involved to pass this amount of air through the cable is prohibitive. This method is effective only in special cases when a small amount of water must be evaporated and where an air dryer is available and time is not important.

Because the limiting factor in the first method considered appeared to be atmospheric pressure, it was proposed that the pressure within the cable be reduced by attaching a vacuum pump to one end of the section to be cleared. Possibly, this would result in faster evaporation of the water at the ambient temperature of the cable. However, due to limitations of equipment which can be used in the field, the pressure could not be reduced sufficiently to increase the rate of evaporation significantly. In other words, the equipment could not produce the pressure differential between the interior of the cable and the ambient air that was required to exhaust the water vapor. Another negative factor in this method is that it requires the operation of portable power-driven equipment in the field over long periods—a procedure which presents difficult operational problems.

Continuing this general approach Laboratories engineers attempted to maintain a reduced pressure in the cable while heating it by passing current through the individual conductors. This would raise the vapor pressure and thereby speed evaporation. Indeed, when 25 watts was impressed on a foot of cable, the rate of evaporation increased significantly. However, this requires a considerable amount of power if, for example, a 500-foot section of cable is to be heated. Because power on working communications conductors presents transmission and personnel safety problems, the method was rejected.

The method finally adopted was one that continued the same exploratory line but slightly shifted the point of attack. It involved the standard laboratory technique mentioned above—the displacement and solution of water in another liquid. To explain this practically: A liquid which has higher vapor pressure than water is passed into one end of the section of water-filled cable; as it passes through the section, the liquid displaces the water. When the water and liquid in solution is driven out of the cable the remaining liquid is evaporated with dry gas or air.

Obviously, the success of this method depends on the new liquid. It must be carefully chosen

Author checks pressure gauge of acetone tanks while removing water from section of PIC cable.

to possess the properties most easily adaptable to the proposed method. In addition, because an initial objective was economy, low cost is an important factor. The desirable properties are:

- ▶ Complete miscibility with water
- ▶ Low viscosity
- ▶ Low boiling point
- ▶ No cracking effect on polyethylene

Such a liquid was known. In fact, a choice was available between two—acetone and methanol. Acetone was chosen because it has a lower boiling point (133 degrees F) than methanol (148 degrees F) and because an equal volume of nitrogen or air will evaporate twice as much acetone as methanol. In addition, acetone is relatively inexpensive and it is easy to obtain commercially. Finally, a given volume of nitrogen will absorb 50 times as much acetone as water.

Tests with Acetone

The effect of acetone on polyethylene was observed by flushing it through a 500-foot length of 152 pair, 22-gauge cable. Then the cable was filled with acetone and sealed for seven months. At the end of this period there was no significant degradation in the appearance or the physical properties of any parts of the cable.

When the method had been decided upon, Laboratories engineers devised procedures for its practical application. This was done largely by experimentation at the test location of the Outside Plant Department in Chester, New Jersey. The method, as it is used at present in the field, is best described by assuming an actual case.

The first indication of water in buried cable at, say, a toll-test center is low insulation resistance or circuit failure, which is indicated by standard electrical maintenance tests. Immediately, additional checks are made which locate the trouble spot. The cable is then exposed and the break in the sheath is repaired before the operation of removing water begins.

Water will flow to a low point in PIC cable. Therefore, if the ground slopes in the vicinity of the break in the sheath the water-filled section may extend from the break to the low spot and even beyond. If the water has traveled a considerable distance through the cable, a convenient length is selected for clearing. This length may vary from 100 to 1000 feet depending on such variables as the slope of the ground along the cable route, location of splices in the cable and the time it takes to purge a given length of cable. To facilitate this part of the job the Laboratories has prepared tables and curves incorporating the variables encountered in determining the proper length of cable. These data are supplied to Outside Plant crews as aids in determining precisely the optimum length to be cleared at one time. The equipment for the job, which is shown in the photograph on page 325, is easily arranged at the site.

Next, pits are dug at each end of the section to be cleared—acetone will be injected into one end and discharged from the other. Epoxy resin pressure plugs are constructed in each end of the section to confine the flow of gas and liquid.

The section is then flushed with nitrogen gas. This displaces the air in the cable and precludes the possibility of a combustible atmosphere of air and acetone vapor. The flushing also pushes some water out of the cable. This, however, is a minor benefit because the gas, following the path of least resistance, tends to ride over the surface of the water rather than push against it.

After the cable is purged, acetone at a pressure of approximately 15 pounds per square inch is injected into one end. The acetone flows through the cable and goes into solution with the water. The solution is discharged at the opposite end. When the water is cleared substantially from the section the liquid flowing from the discharge end changes from clear to brownish, and eventually the steady flow becomes a spurt. A small amount of this spurting discharge is collected and tested for water. This test is quite simple. Anhydrous calcium chloride is put into saturated solution with the discharge mixture; the water in the mixture, heavier than acetone, separates and goes to the bottom.

When the water is cleared from the cable, the remaining acetone is flushed out by nitrogen gas. This flushing may take several days; therefore, cylinders of nitrogen are manifolded together and connected to the cable where they may be left to operate unattended. After all the acetone has been flushed from the section the sheath openings are repaired and the cable is again placed in normal service.

Many miles of PIC cable may have been replaced by the Bell System because of electrical failure caused by water. Experience in the field, however, has shown the practicality of this method of removing water. Because of it, maintenance crews have in many instances stopped the deterioration of working cables and restored them to essentially their original condition.

Like seats on a transcontinental bus, space on a coaxial cable may be used by a number of customers along a route. Reassigning this space economically is done by special filtering techniques.

K. M. Brown

Blocking Filters For Coaxial Cables

Prior to World War II, the long-distance transmission networks of the Bell System consisted primarily of open wire and cables. These systems could transmit up to 16 two-way message channels in the frequency spectrum from 200 cps to approximately 150 kc. Also just before the war, Bell Laboratories developed a carrier system for application on coaxial conductors which provided 480 two-way voice channels per pair. Further development increased this number to 600.

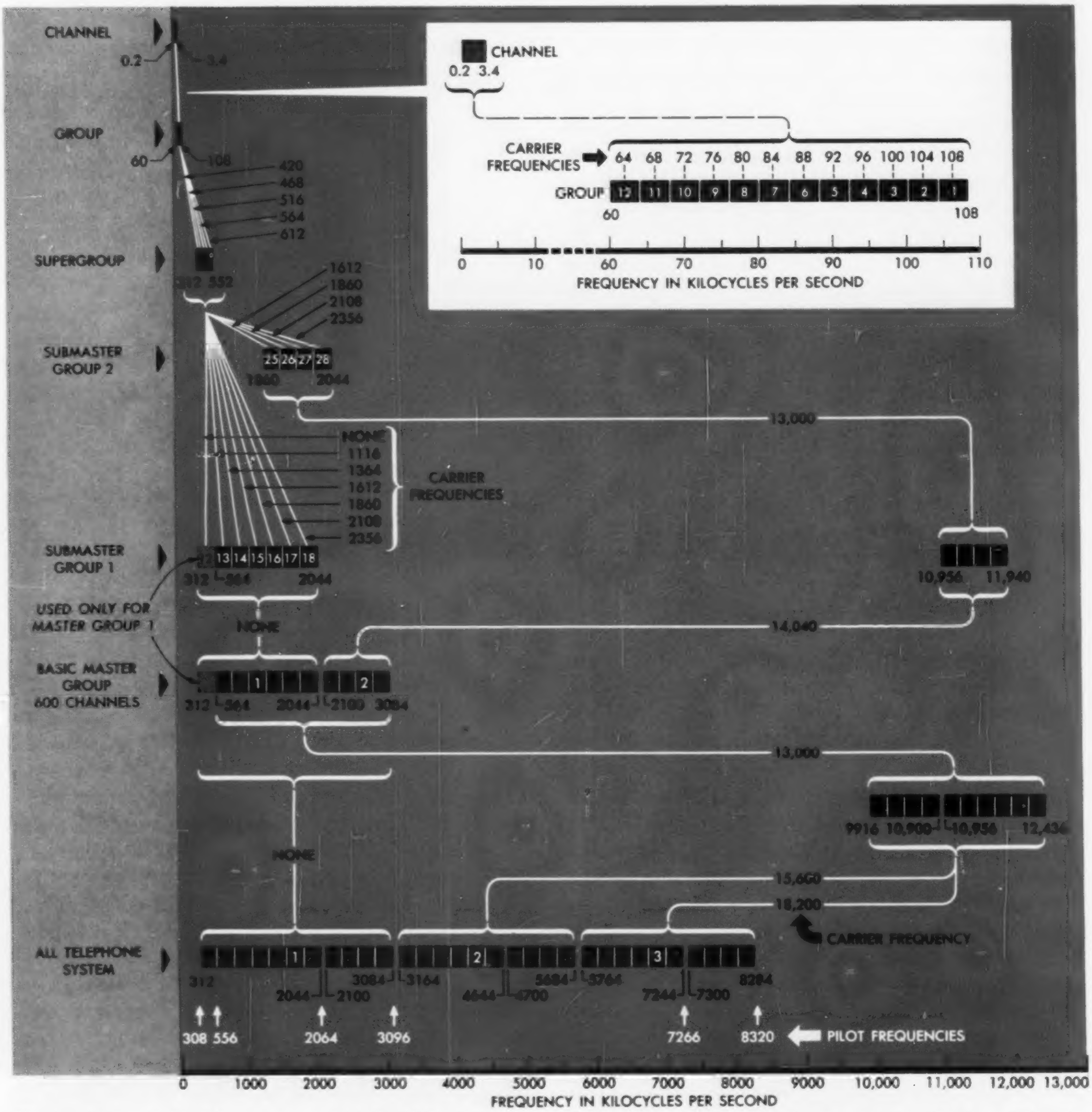
At about the same time, the rapid expansion of the television industry created a demand for a broad-band system of high quality to transmit video information. Also, additional telephone traffic required additional message channels. The coaxial-cable system, with characteristics of low attenuation and adequate shielding, was adaptable for both uses, and therefore the Bell System installed thousands of miles of coaxial cable.

With further advances in the electronic art, designers found that the frequency range of a coaxial system could be more than doubled by designing new amplifiers and doubling their number along the cable route. This new system now made it possible for a coaxial "pipe" to handle 1860 telephone-message channels instead of 600, or one video band plus 600 message channels.

Today we have coaxial cables installed across the country like a superhighway of communications. As on any superhighway, however, we must be able to remove circuits and insert others at any point along it. To achieve this versatility, Bell Laboratories developed special filtering arrangements to drop and re-insert numerous channels along the route of the coaxial cable.

Before looking at a typical filtering arrangement, we might first consider the frequency allocation of the present-day coaxial cable system (see diagram on page 328). First, it has a frequency band extending from 308 to 8320 kc. The basic building blocks of this band are telephone speech channels 4 kc wide, each of which may be subdivided to form a number of telegraph channels. One, two, or three speech channels may be combined to form a high-quality channel for transmitting program material to the stations of a radio broadcasting network. Also, large blocks of message channels may be gathered for television transmission. These channels travel the cable by carrier transmission.

In this system, several steps of modulation are used to "build up" each voice-message channel to its ultimate position in the frequency spectrum of the line. In the first step, each of 12 message channels is modulated to a position in the 60-108 kc range forming a 12-channel group. Five such



How channels build up on coaxial cable system. Data, speech, or program channels are modulated in steps to build them up to their ultimate position in the frequency spectrum of the line.

groups, or 60 channels, are then modulated into a supergroup spectrum that extends from 312 to 552 kc.

In the third step, ten 60-channel supergroups are modulated with appropriate carriers to form Submaster Group 1 and Submaster Group 2. Submaster Group 2 is then double modulated and added to the unmodulated Submaster Group 1 to form a Master Group of 600 voice channels. For Master Group 1 a supergroup is added without modulation to form a 660 Master Group. Master Groups 2 and 3 are constructed from Submaster Groups 1 and 2, double modulated, to form the entire spectrum of 1860 transmission channels.

A typical filtering arrangement on such a system to drop and re-insert channels is shown in the diagram on page 330. In this arrangement, the total frequency spectrum of all three Master Groups (312-8284 kc) or 1860 message channels appears at the input of a receiving hybrid coil (point A) and at the output of a transmitting hybrid coil (point C). These hybrid coils permit two circuits to be connected to the same line without interactions. In addition to the Master Groups are six "pilot" frequencies (308, 556, 2064, 3096, 7266, and 8320 kc) for automatic regulation of

changes in line attenuation caused by changes in temperature.

Assume, for example, that we have an all-message system and we want to drop Submaster Group 2 (2100-3084 kc) or 240 message channels without terminating the system or rendering the frequency space unusable between other points farther along. Such an arrangement would permit 240 message channels to be transmitted from the point of origin to an intermediate station along the route (point B in the diagram) while maintaining through-transmission of all other channels. The dropped Submaster Group 2 may then be replaced by a new Submaster Group 2 inserted from another station (point D) to maintain the full message capacity of the main route.

To accomplish this filtering arrangement, the electronics engineer has various tools at his disposal. The most important of these are the techniques of design. Using these techniques, an engineer can sufficiently attenuate unwanted frequencies to meet the stringent requirements of the system. This ensures the desired over-all quality. He also can match impedances, and control "parasitics," crosstalk, and modulation products. During the development of a filtering system, reductions in cost and size are a prime consideration, but not to the extent of sacrificing good quality or number of channels.

One might better appreciate the critical designs of transmission networks and their part in making a telephone system possible by briefly considering the over-all requirements that have to be met. First, passed-frequency bands must be transmitted at a specific level, with no more than 1.0 db distortion. Second, the blocked bands must be rejected by at least 75 db. Also, impedances are to be matched to 10 per cent or better to all critical frequencies, while crosstalk and modulation products are to be suppressed by at least 100 db, and the temperature effects over the range of 60 to 110 degrees F cannot exceed 0.2 db. Realizing that these are requirements for an entire circuit, one can readily see that the distortion and reflection requirements for the individual networks are extremely stringent.

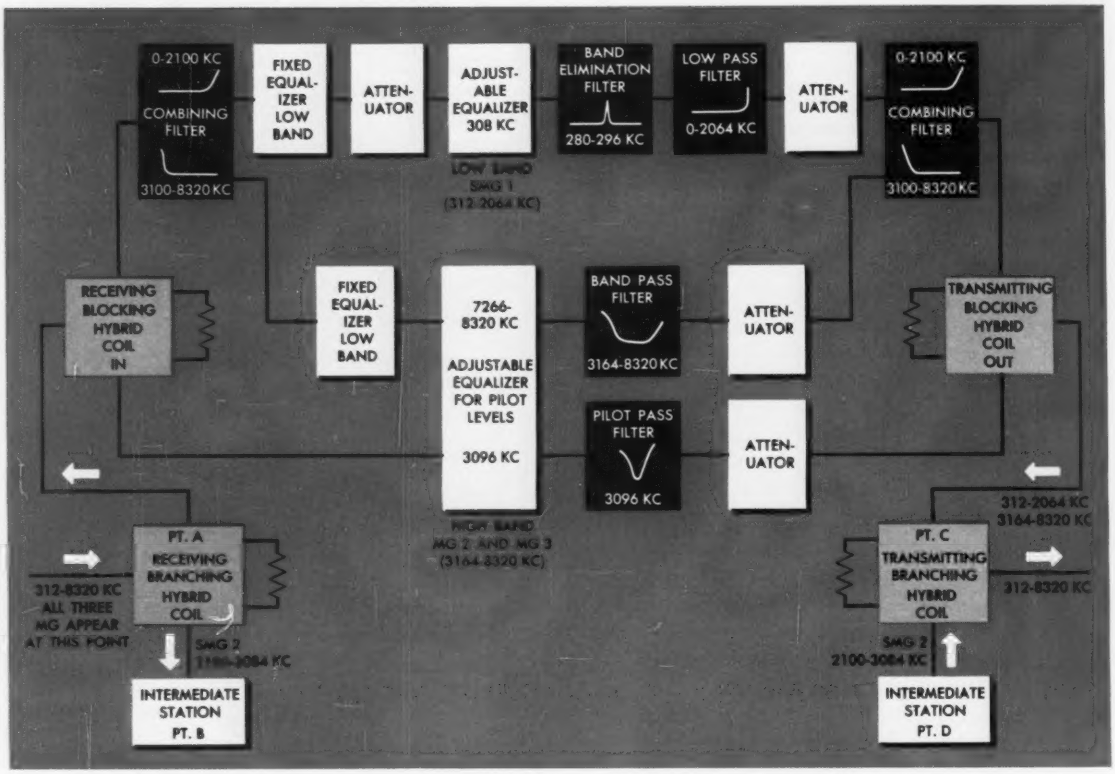
To understand how the filters are arranged, consider the circuit (in the diagram) between the "Receiving Branching Hybrid Coil In" and "Transmitting Branching Hybrid Coil Out." Between these two hybrids are three transmission paths: one for the low band (312-2064 kc), one for the high band (3164-8320 kc) and one for the 3096-kc pilot frequency. The 2100-3084 kc band is blocked from through-transmission.

As the entire frequency spectrum passes from the Receiving Blocking Hybrid In, it separates into a low-frequency band and a high-frequency band by means of a low-pass, high-pass filter combination, designated "combining filter." This filter is primarily intended to permit parallel operation of the two frequency bands while offering a good impedance to the Receiving Blocking Hybrid In. A similar filter is at the output end.

Now consider the low-band branch which uses various transmission networks to achieve the desired characteristics. The low-pass filter, essentially the heart of this branch, has a sharp cut-off characteristic. It transmits the desired frequency band (312 to 2064 kc), including pilot frequencies 308, 556, and 2064 kc, while attenuating everything above 2100 kc by 75 db. The filter employs two end sections, which control the impedance, to satisfy a reflection requirement up to 2064 kc. The filter requires an additional six attenuation sections to suppress the first blocked frequency (2100 kc). A constant-resistance loss equalizer is also used to compensate for distortions across the pass band caused by dissipation in the components.

The combining filters add distortions to the low-band branch and this necessitates the addition of a fixed loss equalizer to compensate for their effects. The pilot frequencies are very important in the regulation of the system, and thus it is essential that they all be passed at the same signal level. The proper level of the 308-kc pilot,

The author with low-pass filter package. This equipment passes the 312-to-2064 kc band and attenuates everything above it by at least 75 db.



Typical filtering arrangement on coaxial cable system to drop and re-insert channels. Hybrid coils permit several transmission circuits to be connected to same line without interactions.

for example, is assured by a variable-loss equalizer centered at this frequency. Also present in this branch are switching signals which are generated and transmitted along with the desired pass band at the switching terminals. A band-elimination filter, centered at 288 kc, confines these signals to an individual switching section.

At the high-pass output of the combining filter we see that the filter in this branch permits transmission of Master Groups 2 and 3 (3164-8320 kc) including pilot frequencies 7266 and 8320 kc, while attenuating all other frequencies. Here, as in the low-pass filter, the separation between the passed frequency band and the stopped band is approximately two per cent. Eight sections of band-pass filtering are required to satisfy this condition. Designers selected these band-pass sections so that parasitic capacitance and inductance can be absorbed in the construction of the filter. Also, an equalizer is necessary in the filter to compensate for distortions caused by dissipation in the components.

One loss equalizer and one adjustable attenuator are also required in this branch; the equalizer to smooth out the 3164-to-8320 kc band distortions resulting from the combining filters, and the attenuator to adjust the pilot frequencies 7266 and 8320 kc to their proper levels.

The fourth pilot frequency, 3096 kc, transmits via a band-pass crystal filter operating at the single frequency of 3096 kc. This filter is connected in parallel with the Receiving Blocking Hybrid In and Transmitting Blocking Hybrid Out. A variable attenuator performs a fine-level adjustment, and fixed attenuators provide large-level adjustments. Loss of signal strength due to the loss in the filters, equalizers and attenuators makes it necessary to add an amplifier at the output of the Transmitting Hybrid Coil to boost the signal strength back to normal.

In this manner it is possible to drop 240 message channels from a total of 1860, and to insert another 240 at an intermediate point. Filtering arrangements using some of the filters, as well as other designs, will permit the dropping of more or less channels as warranted by system traffic conditions. In wire or radio transmission, as well as cable transmission, such arrangements will permit flexibility while efficiently occupying the entire frequency spectrum at all times.

". . . We can achieve the most elegant devices and circuits imaginable and still go broke if we don't have first-rate equipment development to finish the job." So said M. B. McDavitt at a recent Murray Hill symposium designed to take . . .

A New Look at Equipment Development

Over the past few years the Bell System has taken great strides down the road of advancing technology. Particularly rapid progress has shown up in the areas of electronic devices and circuit design. In an effort to have the equipment-development field keep pace with this progress, the Bell System is emphasizing the need to find ways to increase the effectiveness of equipment development.

As one step in this direction, a symposium on equipment development was held recently at the Murray Hill location of Bell Laboratories. A program of twenty-one papers on the subject was presented to a group of over 400 people interested in this field. These engineers represented the Laboratories, A.T.&T., Western Electric, Teletype Corporation and Sandia Corporation.

The stated goal of the symposium was to stimulate the exchange of technical information among the individuals and organizations interested, either directly or indirectly, in equipment development. It was hoped this would encourage the professional growth of equipment-development engineers by sharpening the tools they work with and by enhancing their understanding of the scope and importance of equipment-development activities.

The effects this symposium may have on system design in the Bell Telephone System were summarized in the opening address by M. B. McDavitt, vice president in charge of customer equipment, outside plant, power, and quality assurance. The following passages are from those introductory remarks.

". . . We must increase our strengths in the field of equipment development. Don't misunderstand me. There is much excellent equipment development going on . . . but we can and must do even better work. One worry is the way we have come by equipment development engineers which, I think you will agree, has been too much by the seat of our pants. Furthermore, for leadership, we depend heavily on our older people. We must become stronger right away and, of equal importance, we must lay the foundation without delay for even greater strength in the future.

"The past decade has been remarkable for the advances in electronic technology, both within and outside the Bell System. Sophistication in devices and in circuitry using these devices has jumped ahead in great leaps. But we can achieve the most elegant devices and circuits imaginable and still go broke if we don't have first-rate equipment development to finish the job.

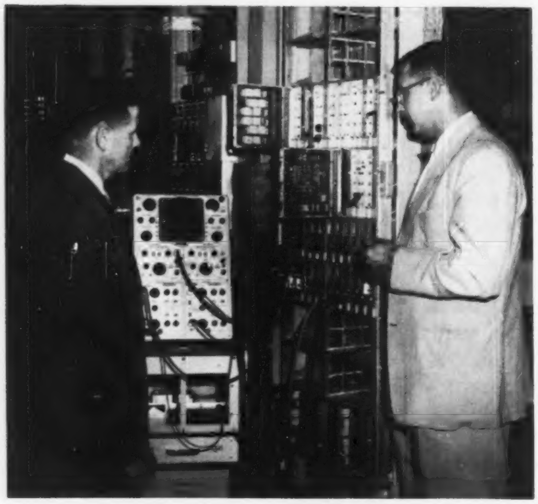
"Device development is the application of pure physics and chemistry and has been bolstered by untold amounts of research and exploratory development. To compete successfully in device development, every man on the team must be

well-trained in the applicable sciences. Publications in this field, useful for training, are legion.

"The progress in circuit application of these devices, likewise, springs from very basic work in information theory, network theory and circuit theory. One can find shelves of worthwhile literature on these fundamental topics.

"Now, I invite you to cite one piece of fundamental writing that lays the foundation for achieving the physical embodiment of circuits for useful service. We can find many papers describing clever ideas. But an aggregation of isolated clever ideas falls far short of a basic approach to the subject of how to put together a good communications system.

"The term [equipment development] is not very descriptive. The practitioners know what it means but they always have a hard time conveying the meaning to others. Mechanical engineering has advanced in sophistication, along with electronics, and we have great need in our business for the very best in mechanical engineers. In my own mind, at least, I associate mechanical engineering with dynamics—moving parts, bearings, gear trains, friction and wear—you name it. Equipment planning and design, on the other hand, deals with essentially static structures somewhat analogous to bridges or chemical plants. These structures must be manufacturable, installable, maintainable and render an important service economically but, except for certain adjuncts, the designer hopes that once in place they don't move perceptibly during their useful life.



Laboratories engineer F. H. King (left) discusses the design aspects of T1 Carrier equipment with J. F. Zahoruiko, Western Electric engineer.

"The skills of the equipment engineer must interlock with those of other kinds of engineers. Just as the designer of a chemical plant must know his chemistry reasonably well, the designer of a piece of communications equipment must know the capabilities and limitations of electronic circuits. As in other engineering disciplines, equipment development is acutely concerned with costs. It deals with properties of materials, heat transfer, shock and vibration and human engineering. As we all know, a successful engineer in any field must have, in addition to basic scientific knowledge, an intuitive feel for what he is doing. Above all, he must like his work.

"Within the past year, Bell Laboratories has taken two important, complementary steps. We have consciously set about to hire top-flight engineering graduates who clearly understand that they are to enter a career of equipment development. And we have revised our educational program so that there is now available graduate training tailored to strengthen the hands of these men in their chosen field. This training leads to a Master's degree and is available at our headquarters locations and at our branch Laboratories.

Another difference between the device and circuit fields, on the one hand, and equipment development, on the other, lies in the mechanisms for exchanging information. This is a most important ingredient of professional development. All of you are thoroughly familiar with the forums—oral and written—available to the former. There are purely scientific groups like the American Physical Society, and applications organizations like AIEE, IRE, and the solid-state device and circuit conferences. The mechanical engineers have their ASME. It was the absence of any such forum that prompted the suggestion to hold this symposium.

"Every equipment-development engineer knows that planning a design and executing it is only part of his job. For example, one of the big ingredients is transmitting information to the manufacturer and to the customer in useful form. Many of our time-honored methods of doing this are proving too slow and not sufficiently effective in today's environment. They are being severely challenged and drastically modified. It would have been easy to devote a full day to this topic alone. This first symposium was deliberately designed to stick closely to the exchange of technical planning and design information and to avoid anything related to procedure. The latter may be an appropriate topic to discuss in the future."

Crystallographers require vast quantities of data from X-ray diffraction studies to determine the structure of materials. Equipment now being developed at Bell Laboratories will apply automation to this time-consuming research area.

Automation in X-ray Crystallography

Research into the atomic structure of crystals will be significantly accelerated by a new X-ray diffraction technique which is almost entirely automatic. Developed by S. C. Abrahams of the Physical Research Department, it involves the use of a high-speed, general purpose, digital computer to generate a control tape which automatically operates a special type of X-ray diffractometer. Data readings from the crystallographic experiment are automatically recorded on a punched tape which is then fed back into the computer. The computer correlates the information, corrects for experimental factors, and prints out crystallographic data in a form convenient for analysis by a crystallographer.

The new technique, called PEXRAD (*P*rogrammed *E*lectronic *X*-*R*ay *A*utomatic *D*iffractometer), was described recently by Mr. Abrahams at the American Crystallographic Association meeting in Boulder, Colorado.

Mr. Abrahams said the equipment is in the final stages of development and is expected to be in operation within a month. He reported that with PEXRAD, it will be possible to obtain more than 17,000 readings a day; and while they are being taken automatically, a crystallographer will be left free to evaluate collected data. With manual methods, the most an experienced crystallographer can hope to obtain is about 3000 readings a day, and then probably only for one or two days at a stretch since the measurements require his complete attention.

In a study of crystals by X-ray diffraction, a beam of Xrays is shot into a crystal. The beam is scattered by the atoms in the crystal; however, if it strikes a crystal plane at a certain angle, the small scattered beams from the atoms combine into a diffracted beam that comes out of the crystal in one direction. In one method, the diffracted beam is detected by a scintillation counter. Then the crystal is rotated slightly and the intensity of the diffracted beam is measured again. After about 50 readings, the crystal and the counter are moved to new angles and the beam that is diffracted by another crystal plane is measured. By this method of measuring the amount and direction of the diffracted beams, a crystallographer can obtain clues as to the positions of the atoms in the crystal.

But this X-ray diffraction method, when done manually, is time-consuming. It also requires painstaking work in setting up the equipment, positioning the crystal for a reading and repositioning it for the next reading. By applying automation to crystallography, Mr. Abrahams expects to facilitate the work and thereby increase significantly our knowledge of the structure of many materials.

S. C. Abrahams, Physical Research Department, examines punched tape similar to output data tape from PEXRAD, *an automated X-ray diffractometer.*

The PEXRAD method operates in the following way: information such as crystal lattice constants, the wavelength of the X-ray beam, and instrumental constants are fed to the computer on punched cards, along with a compiling program. The computer generates a magnetic tape from which a punched paper tape is made. Fed into PEXRAD, it controls the motors which rotate the crystal and receiving counter into position, and then causes an X-ray beam of prescribed wavelength to irradiate the crystal for a precise length of time. The intensity of the beam which is diffracted by the crystal is measured and recorded on punched tape. The crystal is automatically rotated to the next position and the process is repeated.

The punched tape from PEXRAD, containing the readings, is converted to a magnetic tape and is fed back into the digital computer. The computer integrates the intensities, corrects for absorption, rotation, Lorentz and polarization factors, and prints out the corrected data from which the location of the individual atoms can be calculated.

With PEXRAD, a crystal can be oriented with a hundredth of a degree accuracy; therefore, it can be used to study almost any nonbiological crystal. The method could be extended to protein crystals which need about one thousandth of a degree accuracy in crystal positioning, Mr. Abrahams said.

The principles of PEXRAD are similar to an automatic neutron diffractometer method which Mr. Abrahams and E. Prince developed at Bell Laboratories in 1958. Single-crystal, automatic neutron diffractometers are currently being used in a number of research laboratories which have nuclear reactors.

Command Guidance System Directs Explorer XII Into Precise Orbit

Bell Laboratories Command Guidance System last month directed a highly instrumented, 83-pound "laboratory" into a precise, elliptical orbit in a National Aeronautics and Space Administration program to study the behavior of energetic particles in the Van Allen radiation belts and in the space beyond.

The NASA satellite is orbiting the earth with an apogee of 47,800 miles and a perigee of 180 miles. Its orbital period is 26½ hours. The launch was the sixth time the Laboratories Command Guidance System has been used in NASA's space research program.

This latest NASA experiment, originally designated S-3 is designed to gather information on energetic particles, such as electrons and protons, solar winds caused by flares on the sun, and particle properties and population in the Van Allen radiation belts. It is also designed to correlate the particle phenomena with magnetic field observations. The satellite contains ten separate detection systems for six experiments and has a photocell arrangement for maintaining optimum orientation to the earth.

Explorer XII has an octagonal platform about 5½ inches thick and 26 inches across—a usable volume of 1,578 cubic feet—which houses most of the instruments and electronics. The satellite is powered by four paddle wheels containing some 5600 solar cells that charge cadmium batteries.

Radio Command Guidance, originally developed by Bell Laboratories for the Air Force Ballistic Systems Division, is manufactured by the Western Electric Company.

TALKS

Following is a list of speakers, titles and places of presentation for recent talks presented by members of Bell Laboratories.

AMERICAN PHYSICAL SOCIETY MEETING, Mexico City, Mexico.

Frisch, H. L., and Lebowitz, J. L., *Electron Transport at High Temperatures in the Presence of Impurities.*

Gibson, W. M., and Miller, G. L., *Charge Collection in Semiconductor Particle Detectors.*

Gibson, W. M., Thomas, T. D., and Miller, G. L., *Measurement of Mass and Energy of Fragments from Spontaneous Fission of Cf^{252} Using Solid State Detectors.*

Hebel, L. C., *Nuclear Spin Relaxation and Impurities in Metals.*

Hensel, J. C., *Valence Band Parameters from Cyclotron Resonance in Uniaxial Stress Silicon.*

Lebowitz, J. L., see Frisch, H. L.

Miller, G. L., see Gibson, W. M.

Miller, G. L., see Gibson, W. M.

Thomas, D. G., *Excitons and Band Splitting in CdTe.*

Thomas, D. G., see Gibson, W. M.

OTHER TALKS

Ashkin, A., *Experiments on a Low Noise Microwave Quadrupole Amplifier,* Electron Tube Conf., Troy, N. Y.

Augustyniak, W. M., see Logan, R. A.

Batdorf, R. L., and Wiegmann, W., *The Ring-Dot or Rotating Criss-Cross Evaporation Technique,* Solid State Device Res. Conf. I.R.E., Stanford University, Palo Alto, Calif.

Becker, F. K., Davey, J. R., and Saltzberg, B. R., *A two-Phase Vestigial Sideband Data Transmission System Using Synchronous Detection,* A.I.E.E., Detroit, Mich.

Bennett, W. R., Sr., Lecture 2—*Theory of Noise,* Lecture 3—*Response of Devices to Noise,* Lecture 4—*Noise Plus Signal Situations in Radar,* 1961 Sp. Summer Session on Mod. Radar Techniques, University of Pennsylvania, Phil., Pa.

Brown, W. L., see Smits, F. M.

Buchsbaum, S. J., *The Problem of Gas Purity in Plasma Research and Technology,* Materials Science Symposium, Atlantic City, N. J.

Bugnolo, D. S., *Randomly Varying Channel, The Medium Point of View,* Moore School of Elec. Engg., University of Pennsylvania, Phil., Pa.

Carruthers, J. R., *The Direct Observation of Imperfection in Silicon by X-ray Diffraction Topography,* Lehigh University, May 31, 1961.

Collins, R. J., *Emission Characteristics of a Ruby Optical Maser,* Conf. on Optical Instr. & Techniques, London, England.

Collins, R. J., *The Pulsed Optical Maser,* Brooklyn Polytechnic Inst., Brooklyn, N. Y.

Davey, J. R., see Becker, F. K.

Deininger, R. L., *Automation of Telephone Information Bureaus: The Human Factors Problem of an Information Retrieval System,* University of Michigan Engg. Summer Conf. on Human Engg. Concepts & Theory, Ann Arbor, Mich.

Deininger, R. L., *Human Factors in Telephone Systems Engineering,* University of Michigan Engg. Summer Conf. on Human Engg. Concepts & Theory, Ann Arbor, Mich.

Emling, J. W., *Human Factors in Transmission Maintenance,* Symposium on Human Factors in Telephony, Cambridge, England.

Emling, J. W., and Ritchie, A. E., *Future Human Factors Engineering Problems in International Communications,* Symposium on Human Factors in Telephony, Cambridge, England.

Fagen, M. D., see Henneberger, T. C.

Fitzwilliam, J. W., *Satellite Communications,* Midwest Assoc. of Railroad and Utility Commissioners, Lincoln, Neb.; Topsuam Air Force Station, Brunswick, Me.

Fox, A., *A Fatigue Test for Printed Wiring Boards and Through Connections,* A.S.T.M. Annual Meeting, Atlantic City, N. J.

Fulda, S. M., *Some Functions of Systems Engineering in Industry and in the Military,* Res. & Development Sem. Series, Newark Air Force Res. Center, Newark, N. J.

Geballe, T. H., and Matthias, B. T., *The Isotope Effect in Osmium and Zinc,* I.B.M. Superconductivity Conf., Yorktown Heights, N. Y.

Gershenzon, M., *Electroluminescence from p-n Junctions in Gallium Phosphide,* I.R.E. Device Conf., Stanford University, Stanford, Calif.

Gershenzon, M., *Precipitation in Gallium Phosphide,* Electrochem. Soc., Indianapolis, Ind.

Geschwind, S., *Paramagnetic Resonance of Fe^{3+} in Yttrium Gallium Garnet (YGaG) and Anisotrophy of Yttrium Iron Garnet (YIG),* RCA Labs., Princeton, N. J.

Gilbert, J. F., see Logan, R. A.

Gohn, G. R., *Stress Relaxation—Some New Test Methods for the Determination of this Mechanical Property Either in Tension or Compression,* A.S.T.M. Annual Meeting, Atlantic City, N. J.

Gupta, S. S., *Section and Ranking Problems—Single Sample Procedures for Normal Means,* Cornell University Seminars in Ind. Engg., Ithaca, N. Y.

Gupta, S. S., *Single Sample Procedures for Normal Variances*, Cornell University Seminars in Ind. Engg., Ithaca, N. Y.

Gupta, S. S., *On Multivariate Normal Probability Integral*, Inst. Math. Statistics Annual Meeting, Seattle, Wash.

Hebel, L. C., *Magnetic Resonance in Superconductors*, I.B.M. Superconductivity Conf., Yorktown Heights, N. Y.

Henneberger, T. C., and Fagen, M. D., *Comparative Transmission Characteristics of Polyethylene Insulated and Paper Insulated Communication Cables*, A.I.E.E. Summer General Meeting, Ithaca, N. Y.

Jaccarino, V., *NMR in Intermetallic Compounds*, Gordon Research Conf. on Magnetic Resonance, New Hampton, N. H.

Kaminow, I. P., *Microwave Modulation of Light Using the Pockels Effect in KDP*, Electron Device Conf., Troy, N. Y.

Kisliuk, P., *The Ruby Maser as a Light Amplifier*, I.R.E./A.I.E.E. Electron Device Conf., Troy, N. Y.

Klein, D. A., Kolb, G. A., Pompliano, L. A., and Sullivan, M. V., *Electropolishing n-type Germanium and p- and n-type Silicon*, Electrochem. Soc. Meeting, Indianapolis, Ind.

Kluver, J. W., *Experimental Results from the M-Type Parametric Amplifier*, Electron Device Conf., Troy, N. Y.

Knox, W. P., Weiss, N. M., and Struthers, J. D., *X Radiation Surveys of Microwave Generators*, Annual Meeting, Health Physics Society, Las Vegas, Nev.

Kolb, G. A., see Klein, D. A.

Kretzmer, E. R., *The Use of Error Correcting Codes in Ferrite Core Translators*, Eighth Annual Symposium on Computers & Data Processing, Estes Park, Colo.

Kunzler, J. E., *Superconductivity in High Magnetic Fields at High Current Densities*, I.B.M. Superconductivity Conf., Yorktown Heights, N. Y.

Kurtz, S. K., *A Quasi-Particle Model for Studying Harmonic Cross-Relaxation*, Electron Device Conf., Troy, N. Y.

Laudise, R. A., *Hydrothermal Crystallization*, Union Carbide Res. Center, Cleveland, Ohio.

Lee, C. A., *An Approximate De Analysis of a One-Dimensional Strip Line Esaki Diode*, I.R.E. Device Conf., Stanford University, Stanford, Calif.

Levenbach, G. J., *Multifactor Life Testing*, The Statistics Institute of New York University, N. Y. C.

Logan, R. A., Augustyniak, W. M., and Gilbert, J. F., *Electron Bombardment Damage in Silicon Esaki Diodes*, A.P.S., Monterey, Calif.

Logan, R. A., see Spitzer, W. G.

Lowry, W. K., *Communication in Industry Tomorrow*, A.S.E.E. Annual Meeting, University of Kentucky, Lexington, Ky.

Mallows, C. L., *Tchebycheff Inequalities in a Generalized Moment Problem*, I.M.S. Meeting, Seattle, Wash.

McAdoo, K. L., *Speech Volumes on Bell System Message Circuits*, A.I.E.E. Summer General Meeting, Ithaca, N. Y.

Nelson, D. F., *Infrared and Optical Masers*, I.R.E., Detroit, Mich.

Nelson, D. F., *The Optical Maser*, I.R.E., Washington, D. C.

Nelson, D. F., *The Pulsed Ruby Optical Maser*, Second International Conf. on Quantum Electronics, Berkeley, Calif.

Nelson, W. L., *Optimal Control Methods for On-Off Sampling Systems*, 1961 Joint Automatic Control Conf., University of Colorado, Boulder, Colo.

Pompliano, L. A., see Klein, D. A.

Pompliano, L. A., see Sullivan, M. V.

Ritchie, A. E., see Emling, J. W.

Robin, M. B., *The Color and Electronic Configurations of Prussian Blue*, Symposium on Molecular Structure & Spectroscopy, Ohio State University, Columbus, Ohio.

Rosenberg, S., *Two-Person Interactions in a Continuous-Response Task*, Symposium on Mathematical Methods in Small Group Processes, Stanford University, Palo Alta, Calif.

Saltzberg, B. R., see Becker, F. K.

Schawlow, A. L., *Optical Masers*, Conf. on Optical Instruments & Techniques, London, England; National Physics Lab., Teddington, England.

Schwenker, J. E., and White, E. W., *Recent Experimental Results on a Cylindrical Film Memory*, Eighth Annual Symposium on Computers & Data Processing, Estes Park, Colo.

Sheldon, H. E., *The Bell Telephone Laboratories*, Kiwanis Club, Ocean City, N. J.

Smith, G. E., *The Thermoelectric Power of Bismuth Antimony Alloys at Low Temperature*, A.P.S., Monterey, Calif.

Smith, K. D., *Solar Batteries*, Capitol Radio Engg. Inst. Dinner Meeting of Students & Alumni, Mountainside, N. J.

Smith, K. D., see Smits, F. M.

Smits, F. M., Smith, K. D., and Brown, W. L., *Solar Cells for Communication Satellites in the Van Allen Belt*, British I.R.E. Conf. on Radio Techniques & Space Res., University of Oxford, England.

Spencer, E. G., *Ferromagnetic Relaxation in Yttrium Iron Garnet and the Relation to Applications*, Proc. Inst. of Elec. Enggs. Supplement, Conf. on Materials & Components, London, England.

Spitzer, W. G., Trumbore, F. A., and Logan, R. A., *Electrical*

and Optical Properties of Heavily Doped Germanium, A.P.S., Monterey, Calif.

Struthers, J. D., see Knox, W. P.

Sullivan, M. V., and Pompliano, L. A., *A Chemical Polishing Technique for Gallium Arsenide*, Electrochem. Soc. Semiconductor Symposium, Indianapolis, Ind.

Sullivan, M. V., see Klein, D. A.

Tabor, W. J., *Optimization of Maser Action in Ruby*, Electron Device Conf., Troy, N. Y.

Tebo, J. D., *The Nike Missile Family*, Old Guard of Summit, Summit, N. J.; Western Electric Engineers, N. Y. C.

Tebo, J. D., *Satellite Communications*, Rotary Club, Elizabeth, N. J.; Ceramic Assoc. of New Jersey, Harmony, N. J.

Tischendorf, J. A., *Acceptance Sampling in Life Tests*, Cornell University Seminars in Ind. Engg., Ithaca, N. Y.

Tischendorf, J. A., *The Effect of Sample Censoring Upon the Efficiency of Estimating Mean Life Under Several Lifetime Assumptions*, Math. & Statistics of Reliability Problems Conf., N. Y. C.

Trumbore, F. A., see Spitzer, W. G.

Weiss, M. M., see Knox, W. P.

Weissman, G. F., *The Damping Capacity of Some Granular Soils*, A.S.T.M. Annual Meeting, Atlantic City, N. J.

West, J. M., *Engineering Education*, Western Electric Co. Grad. Engg. Train. Prog., Winston-Salem, N. C.

White, E. W., see Schwenker, J. E.

Wiegmann, W., see Batdorf, R. L.

Williams, W. H., *Remarks on the Efficiency of Unbiased Estimation with Auxiliary Variates*, I.M.S. Meeting, Seattle, Wash.

Wright, J. P., *Chemistry and Your Telephone*, Rotary Club, Greenville, Tex.

PATENTS

Following is a list of the inventors, titles and patent numbers of patents recently issued to members of the Laboratories.

Andrews, F. T. Jr. and Summer, E. E.—*Timing of Regenerative*—2,992,341.

Berkery, E. A. and Carlen, I. E.—*Switching Apparatus*—2,993,-145.

Berry, R. W.—*Method of Making A Capacitor Employing Film-Forming Metal Electrode*—2,-993,266.

Blake, H. A.—*Loudspeaker System*—2,993,961.

Carlen, I. E. see Berkery, E. A.

Chapin, D. M.—*Torpedo Control Circuit*—2,991,741.

Danielsen, D.—*Frequency Selective Signaling System*—2,993,-094.

Dreyfuss, H. and Hose, R. H.—*Telephone Handset*—D-190,810.

Feiner, A.—*Magnetically Controlled Switching Device*—2,-992,306.

Feinstein, J.—*Electron Beam Devices*—2,992,355.

Flint, E. W.—*Reading Recorded Data*—2,991,450.

Flint, E. W. and Hague, A. E.—*Sorting Recorded Data*—2,991,-451.

Geyling, F. T.—*Passive Repeater for Satellite Communication Systems*—2,991,027.

Goldey, J. M. and Ross, I. M.—*Semiconductor Switch*—2,993,-154.

Groth, W. B. and Seckler, H. N.—*Selector for Switching Network*—2,992,410.

Hague, A. E. see Flint, E. W.

Hose, R. H. see Dreyfuss, H.

Lee, B. W.—*Selector Circuit*—2,991,449.

Linares, R. C. Jr. and Nielsen, J. W.—*Barium Titanate Single Crystals*—2,992,079.

Lundry, W. R.—*Delay Network*—2,991,425.

Meyers, S. T.—*Binary Adder Circuits*—2,992,339.

Miller, S. E.—*Scanning Antenna*—2,994,084.

Miller, S. E.—*Electromagnetic Wave Filter*—2,991,431.

Mosing, L. W.—*Telephone Set*—D-190,867.

Nielsen, J. W. see Linares, R. C. Jr.

Olasin, D.—*Slip Ring Brush Assembly*—2,994,055.

Polk, R. E.—*Artificial Larynx*—D—190,812.

Riesz, R. P.—*Formation of P-N Junctions in P-Type Semiconductors*—2,992,471.

Ross, I. M. see Goldey, J. M.

Seckler, H. N. see Groth, W. B.

Steinberg, J. C.—*Torpedo Control Circuit*—2,991,742.

Straube, H. M.—*Dual Transistor Switch*—2,994,044.

Sumner, E. E. see Andrews, F. T. Jr.

Treptow, A. W.—*Metallizing Refractory Substrates*—2,993,815.

Van Tassel, E. K. and Yaeger, R. E.—*Oscillator Amplitude Control*—2,992,399.

Van Uitert, L. G.—*Electrical-Transmission Devices Utilizing Gyromagnetic Ferrites*—2,994,-045.

Weiss, M. T.—*Non-reciprocal Wave Transmission*—2,993,180.

Whitney, W.—*Induction Type Translator*—2,992,421.

Yeager, R. E. see Van Tassel E. K.

Yaeger, R. E.—*PCM Decoders with Bipolar Output*—2,991,-422.

PAPERS

Following is a list of the authors, titles and places of publication of recent papers published by members of the Laboratories.

Ahearn, A. J., *Mass Spectrographic Analysis of Insulators Using a Vacuum Spark Positive Ion Source*, J. Appl. Phys., 32, pp. 1195-1197, July, 1961.

Ahearn, A. J., *Mass Spectrographic Detection of Impurities in Liquids*, J. Appl. Phys., 32, pp. 1197-1201, July, 1961.

Alff, C., see Wertheim, G. K.

Augustyniak, W. M., see Logan, R. A.

Baruch, P., *Mobility of Radiation Induced Defects in Germanium*, J. Appl. Phys., 4, pp. 653-659, Apr., 1961.

Batterman, B. W., *The Effect of Long Wavelength Harmonics on Double Crystal Diffractometer Measurements*, Rev. Sci. Instru., 32, pp. 393-396, Apr., 1961.

Batterman, B. W., *Imaginary Part of X-ray Scattering Factor for Germanium: Comparison of Theory and Experiment*, J. Appl., Phys., 32, pp. 998-1001, June, 1961.

Bennett, W. R., Sr., *Electrical Noise*, McGraw-Hill Book Co., Oct., 1960.

Benson, R. J., *Factors Contributing to Backlash in Gear Trains*, Electro-Tech., 68, pp. 66-73, July, 1961.

Bhuta, P. G., *Nonsteady Two-Dimensional Jet Mixing Theory for Laminar and Turbulent Flows*, Doctoral Dissertation, Steven Inst. Tech., pp. 1-133, June, 1961.

Burbank, R. D., *Molecular Chain Folding in Linear Polyethylene*, J. Poly. Sci., XLVI, pp. 256-257, 1960.

Clogston, A. M., see Matthias, B. T.

Corenzwit, E., see Matthias, B. T.

Cowell, W. R., *The Use of Group Codes in Error Detection and Message Retransmission*, Trans. I.R.E., IT-7, pp. 168-171, July, 1961.

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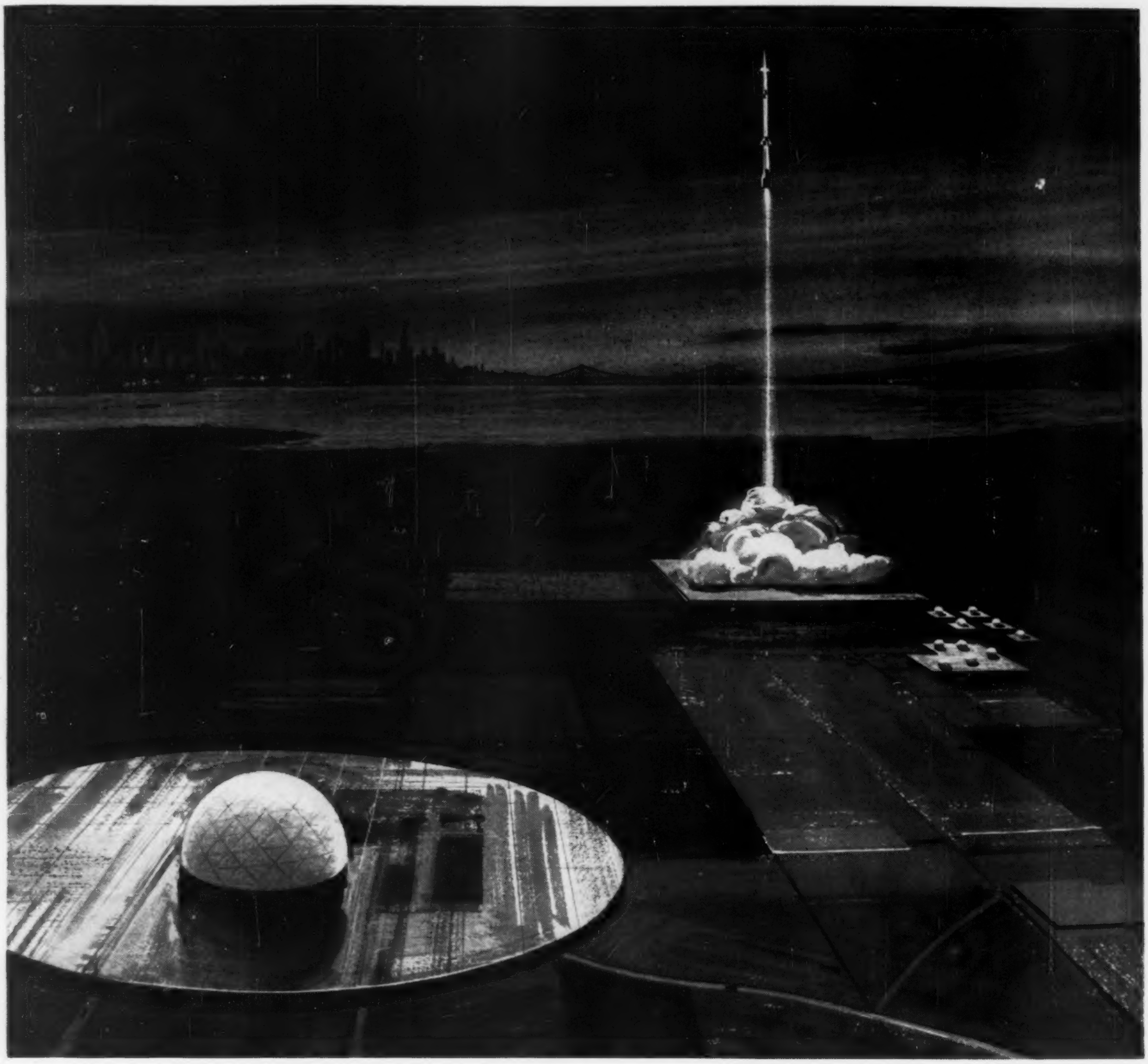

More than 450,000 pounds of thrust lifts the U. S. Army's Nike Zeus missile skyward in a cloud of vapor. The Nike Zeus missile being developed for the project by the Douglas Aircraft Company will be designed to intercept ballistic missiles traveling over 15,000 miles per hour, and destroy them at a safe distance from the defended area.

How do you stop an ICBM?

How do you detect, track, intercept—and destroy within minutes—an ICBM that is moving through outer space ten times faster than a bullet?

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Radically new radar techniques are being developed for Nike Zeus. There will be an acquisition radar designed to detect the invading missile at great distances. And a discrimination radar designed to distinguish actual warheads from harmless decoys that may be included to confuse our defenses.

The system tracks the ICBM or IRBM, then launches and tracks the Nike Zeus missile and automatically steers it all the way to intercept the target. The entire engagement, from detection to destruction, would take place within minutes and would span hundreds of miles.

Under a prime Army Ordnance contract with the Western Electric Company, Bell Laboratories is charged with the development of the entire Nike Zeus system, with assistance from many subcontractors. It is another example of the cooperation between Bell Laboratories and Western Electric for the defense of America.

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